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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 272

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. ▼ September 27, 1915

THE SOUTHERN CYPRESS

By

WILBUR R. MATTOON, Forest Examiner

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By WILBUR R. MATTOON, *Forest Examiner.*

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IMPORTANCE.

In the amount of lumber produced in 1913 cypress ranked sixth of the conifers or softwoods. On account of the durability of the heartwood and its moderate softness, which makes it easily worked, cypress is a wood of high intrinsic value. Cypress trees not uncommonly reach an age of over a thousand years, a height of from 120 to 130 feet, and a diameter above the basal swell of from 8 to 10 feet. Cypress is very persistent in growth, and is one of the few conifers which successfully sprouts from the stump.

Cypress is restricted in its natural occurrence to deep, rich swamp lands. The problem of bringing it under forest management is therefore intimately related to that of reclaiming swamp land on an extensive scale by drainage. Though preeminently a tree of the swamp, when planted it thrives in as wide a range of climate and soil as

[1] Southern cypress (*Taxodium distichum* Rich.), of the southeastern United States is known among botanists as "bald" cypress because in contrast to most conifers, which are evergreen, it sheds its leaves annually.

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most of our forest trees. Naturally, however, it occurs in commercially important quantities only in regions where logging is difficult and expensive.

Because of its power to develop special organs or parts, cypress possesses unusual ability to adapt itself to conditions of soil and water generally considered extremely unfavorable to tree growth. As a result, the tree occurs in various forms differing quite widely in respect to leaf, bark, shape, size, and to a limited extent, in wood characteristics. In soft, unstable soils and locations subject to periods of high water, cypress develops peculiar knees which appear to serve the double function of organs for breathing and anchorage. Although its home is in unstable soils, the tree is seldom if ever thrown by wind.

Cypress is interesting, botanically, as one of the few surving members of a race of trees which was prominent in geologic times. Among its associates were the redwoods of California. Only two other close relatives are known, one an evergreen cypress on the tablelands of Mexico and the other a tree occurring in China.

Cypress is readily grown from seed and is well adapted to nursery practice. By many authorities it is considered one of the most beautiful and ornamental trees for park planting, for which it has been used quite widely over the eastern and central portions of the United States. Although cypress has not been raised in forest plantations on a large commercial scale, experience thus far points to the commercial success of forest planting, under certain conditions, in the deeper and fresher soils.

GEOGRAPHICAL AND COMMERCIAL RANGE.

The geographical range of cypress extends from southern New Jersey [1] over the Atlantic coastal plain to Florida, thence south to the extreme southern end of the Florida peninsula,[2] and westward through the Gulf Coast region nearly to the Mexican border in Texas, and up the central Mississippi Valley to southern Illinois and Indiana. This range covers all of Florida, Mississippi, and Louisiana, the southern half of Georgia, and Alabama, and lesser portions of 11 other States. Locally, cypress is confined strictly to river and interior swamps, wet depressions, and stream banks.

The commercial range of cypress is much more restricted than the botanical range. The district of heavy commercial stands centers in the lower Mississippi Valley and Florida, where deep swamps abound. The large coastal river and isolated inland swamp districts are regions of important commercial production. These in-

[1] Shaler, Dr. N. S., Memoirs of the Museum of Comparative Zoology, Harvard University, Vol. XVI No. 1, p. 11; also Witmer Stone, "Plants of Southern New Jersey," Report of New Jersey State Museum for 1910, p. 151.

[2] Harper, Roland M.

clude the Lumber River and the Wilmington swamps (North Carolina), Peedee, Santee, and Salkehatchie Rivers (South Carolina), Okefinokee Swamp and Flint River (Georgia), Suwanee and Apalachicola Rivers and parts of the Florida peninsula, and the alluvial flood plain of the Mississippi, at scattering points below the St. Francis Basin in Missouri, but preeminently over the broad, deep swamp area south of Baton Rouge in Louisiana.

The introduction of larger and more efficient logging machinery has advanced the logging in any specified region from the water

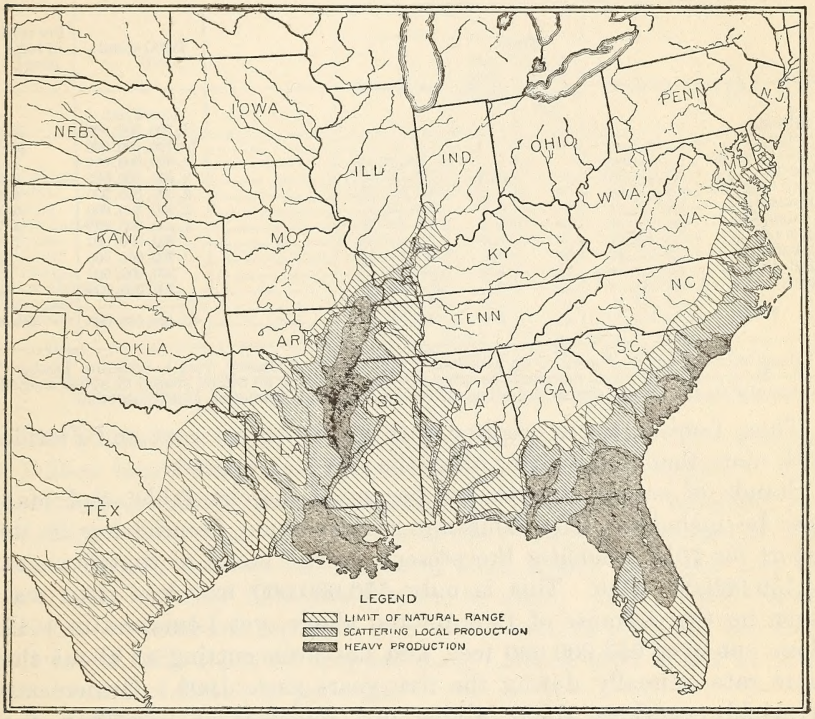


FIG 1.—Geographical and commercial distribution of cypress in the United States.

fronts into the deeper and less accessible swamp areas. Thus, the evolution in logging methods chiefly accounts for the continued commercial importance of cypress in regions where lumbering was actively in progress many years ago.

PRESENT SUPPLY AND ANNUAL CUT.

STANDING TIMBER.

The total present stand of cypress, according to the best available estimates, is about 40,000,000,000 board feet, of which about 1,000,000,000 feet are being cut annually.

The general inaccessibility of swamps and the difficulty of cruising by ordinary methods have probably strengthened in the case of cypress the general tendency to underestimate timber. Successive estimates of the total stand have constantly increased, in spite of the heavy annual cut. In 1897 an investigation placed the amount of standing cypress at 33,000,000,000 feet.[1] In 1909, however, the Bureau of Corporations estimated the amount of standing cypress at 40,000,000,000 feet, distributed by States as shown in Table 1.

TABLE 1.—*Total estimated amount of standing cypress, by States.*[1]

State.	Total stand.	Per cent of total stand.
	Board feet.	
Louisiana	15,700,000,000	38.9
Florida	10,700,000,000	26.5
North Carolina	3,000,000,000	7.4
Georgia	2,800,000,000	6.9
South Carolina	2,600,000,000	6.4
Arkansas	2,200,000,000	5.5
Mississippi	1,900,000,000	4.7
Missouri	900,000,000	2.2
Alabama	200,000,000	.5
Virginia	200,000,000	.5
Texas	200,000,000	.5
Total	40,400,000,000	100.0

[1] Department of Labor, Bureau of Corporations, "The Lumber Industry, Part I, Standing Timber," p. 76. To these figures, which represent the stand privately owned in all States, should be added a small amount of State and Federal timber and private timber in Maryland, Tennessee, and Kentucky.

Thus, Louisiana was credited with nearly 40 per cent and Florida with more than one-quarter of all the standing cypress.

Stands of second growth are becoming merchantable, and may now be included. The Louisiana Conservation Commission in its report for 1914 estimates the present cypress stand of that State at 14,130,000,000 feet. This is only 570,000,000 feet less than was given by the estimate of 1909 quoted above, yet Louisiana in 1912 alone cut over 653,000,000 feet, and has been cutting at about the same rate annually during the five years since 1909. Owners are invariably cautious about giving out information regarding the amounts of timber in their holdings. This situation and the factor of annual growth being taken into account, the total stand of cypress in 1914 is believed to be not less than 40,000,000,000 feet.

ANNUAL CUT.

The total cut of cypress lumber in 1913, exclusive of lath and shingles, was 1,097,247,000 board feet.[2] Since shingles and lath are made from the slabs and other kinds of "mill waste," and poles and ties are usually cut from small sizes not considered in the original

[1] Mohr, Dr. Charles, Report for the Forest Service, U. S. Department of Agriculture.

[2] The Bureau of Crop Estimates, in cooperation with the Forest Service, U. S. Department of Agriculture, based upon reports of 607 mills. Reports from mills cutting less than 50,000 feet not included.

estimates, the relation of cut to the total standing timber is unaffected by the lack of any figures for these smaller products. On the basis of the estimate given above, the present annual cut amounts to about 2.7 per cent of the standing timber. During the decade following 1899 the annual cut practically doubled (92.7 per cent increase), rising from a little less than 500,000,000 feet to 955,635,000 board feet. Table 2 shows the cut of the various States in 1913.

TABLE 2.—*Quantity of cypress lumber sawed in 1913 and in 1909.*

State.	1913			1909		
	Quantity.	Per cent of total.	Active mills reporting.	Quantity.	Per cent of total.	Active mills reporting.
	Board feet.			*Board feet.*		
Louisiana	744,581,000	67.9	94	608,854,000	63.7	153
Florida	100,723,000	9.2	41	84,811,000	8.9	85
Georgia	74,818,000	6.8	57	27,517,000	2.9	84
South Carolina	39,895,000	3.6	43	36,040,000	3.8	55
Arkansas	35,964,000	3.3	98	55,012,000	5.7	309
Missouri	28,814,000	2.6	49	32,819,000	3.4	125
Mississippi	25,782,000	2.3	54	41,666,000	4.4	209
North Carolina	19,213,000	1.8	62	34,506,000	3.6	150
Tennessee	14,502,000	1.3	44	8,709,000	0.9	73
All others[1]	12,955,000	1.2	65	25,629,000	2.7	261
Total	1,097,247,000	100.0	607	955,635,000	100.0	1,504

[1] Includes mills in Maryland, Virginia, Alabama, Texas, Indiana, Illinois, and Kentucky.

For all the States the average production per mill in 1912 exceeded a million board feet, in Louisiana it was 5,785,000 board feet.[1] This is exceeded only in the manufacture of Douglas fir, redwood, and southern yellow pine. In Louisiana, the average cut per mill in 1909 was 3,900,000 feet for 153 mills; in 1912, nearly 5,800,000 feet for 113 mills; in 1913,[2] 7,900,000 feet for 94 mills. In the whole region though the total cut reported increased about 15 per cent, the total number of mills reported dropped from 1,504 in 1909 to 607 in 1913, a reduction of about 59 per cent.[2]

In 1913 for the first time the annual cut reached 1,000,000,000 feet, over 100,000,000 more than the 1912 cut, the highest reported up to that time. The number of active mills reporting in 1913, however, was 372 less than in 1912. Increases in cut over 1912 were large on the Atlantic coast, in South Carolina and Georgia,[3] and in the Mississippi basin in Louisiana, Mississippi, and Tennessee. In the five years ending in 1913, the annual cut very nearly tripled in size in Georgia, increased 25 per cent in Florida, and 67 per cent in Tennessee. Decreases of 44 per cent in North Carolina and 53 per cent in Arkansas occurred in the same period.

[1] 1,018,000 board feet, as compared with 635,400 board feet in 1909.

[2] Mills cutting less than 50,000 feet of lumber annually not included in 1913 statistics; 1909 figures from complete decennial census.

[3] Partly because of the opening up of the Okefinokee Swamp.

PHYSICAL AND MECHANICAL PROPERTIES OF THE WOOD.

Cypress wood is strong and stiff, moderate in weight and hardness, and very moderately subject to shrinkage. It is usually fine-grained, light to dark brown in color, and durable under trying conditions of moisture. The wood is easily worked.

COLOR.

Cypress averages darker in color in the Gulf and South Atlantic region, and correspondingly lighter as one passes northward up the Mississippi and Atlantic coast. In any specified locality, however, wide color variations occur, although usually one color predominates. For example, the cypress of the deep St. Johns River swamps, Florida, averages an amber or light orange-brown, and is referred to under the trade name of "yellow" cypress. Nearby, in shallower isolated swamps of different soil and moisture conditions, the wood is decidedly darker, with a more pronounced grain when sawed. Along the lower Apalachicola River and in similar deep alluvial river plains, the prevailing orange-brown of the heartwood is occasionally varied to the deepest brown or chocolate color, often streaked on a lighter background. This wood is very handsome in its color markings and mottling. Much of the lumber from the lower Mississippi delta and other southern regions shows prominently the harder and darker reddish colored bands of the heavier summerwood in each annual ring, and has come to be known commercially as "red" cypress. The annual rings of cypress and a marked irregularity of growth give to the wood a richly grained effect, for which it is widely sought for interior finish.

The wood from both of the northern regions is spoken of in the market as "white cypress." In logging, this term means that the wood floats high. Along the Atlantic coast "black" cypress refers to heavy wood which sinks, or floats very low if at all. In the Gulf regions "black" cypress refers more especially to distinctions in color rather than buoyancy, since in respect to weight dark wood is often not noticeably heavier than the lighter shades. The cause for variations in color can not now be completely pointed out.

WEIGHT.

The wood varies in weight usually from 22 to 37 pounds, averaging about 28 pounds per cubic foot, when thoroughly air-dried. The equivalent specific gravity is 0.35 to 0.60, averaging about 0.45. Cypress wood ranges about midway between the white and the hard yellow pines. It is a little lighter than eastern red cedar, but considerably heavier than redwood, western red cedar, eastern spruce, and eastern white cedar. Green or unseasoned cypress varies in

weight from about 50 pounds per cubic foot to more than 62.35 pounds, the weight of an equal amount of water.

In a series of tests the Forest Service [1] found that cypress wood taken from all parts of the individual tree was strikingly uniform in weight, structure of rings, and strength.

As a rule the wood of cypress growing in ponds and other swamps with acid soils averages much heavier than that of the typical form growing along fresh, active streams. The wood from six representative trees growing in strongly acid pond soils in South Carolina averaged 0.50 in specific gravity [2] as compared with 0.44 [3] specific gravity for four typical river cypresses from the fresh water of the Savannah River bottom in the same region. The heaviest wood (specific gravity 0.55) in 39 representative trees taken from four southern States was in a tree growing very slowly in a pine-barren pond in South Carolina. In the Dead Lakes of western Florida, where an extensive cypress forest has been gradually inundated, very slow growth in fresh, clear water produced soft, light-weight wood. In swell butts, knees, and large roots, where growth is rapid, the wood is very much below the average in weight. The lightest of this wood is used to a limited extent as a substitute for cork, especially for making fish-net floats and the like. One piece showed a specific gravity under test of 0.19, or only 10 pounds per cubic foot, which is considerably lighter than cork. During several months in the year the water in the great overflow belt along the Mississippi becomes increasingly stagnant and charged with humus compounds in solution, resulting in moderately unfavorable conditions for growth. This region produces much of the characteristic darker colored "red" cypress of good average weight and strength.

STRENGTH.

In respect to strength cypress holds a position intermediate between that of the white and the heavy yellow pines. The close relation between weight and strength both in compression and cross-bending, as shown by tests on cypress in a green state, is set out in Table 3.

[1] Forest Service Circular 19, "Progress in Timber Physics: Bald Cypress," by Filibert Roth, p. 22.
[2] Ranging from 0.42 to 0.58.
[3] Ranging from 0.39 to 0.48.

TABLE 3.—*Average strength values of green cypress in compression endwise and in bending for pieces of different weight.*[1]

Wood (air-dry).		Compression parallel to grain (crushing strength at maximum load, per square inch).	Bending.	
Specific gravity.	Weight per cubic foot.		Fiber stress at elastic limit per square inch.	Modulus of rupture per square inch.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
0.58	36.2	6,500	6,800	7,800
.54	33.7	4,800	5,600	7,100
.50	31.2	4,700	5,000	6,300
.44	27.5	4,200	----------	----------
.41	25.6	3,800	4,500	5,800
.37	23.1	3,200	3,800	5,100
.35	21.9	2,900	3,600	5,000

[1] Forest Service Circular 19. Strength tests on cypress have not yet been made at the Forest Products Laboratory in connection with the series for commercial woods of the United States, and the figures given in Tables 3 and 4 can not be compared with those for other kinds of wood so far obtained in the latter series, since conditions of test were different.

In the above tests the varying strength values of green cypress are shown to be correlated pretty closely with the varying weights and densities of the wood. Trees on adjacent but dissimilar sites are known to produce wood differing markedly in strength. The first test was with a small cypress over four centuries old, grown in a "pond" in South Carolina, which proved to be the heaviest and likewise the strongest and stiffest timber tested.

Similar tests made with air-dry wood (12 per cent moisture) from 16 cypress trees selected from various portions of the range show, in Table 3, the variation in strength values and their general correlation with weight.

TABLE 4.—*Average strength values of air-dry (12 per cent moisture) cypress.*[1]

Wood (air-dry).		Average strength in pounds per square inch.			
		Compression parallel to grain (crushing strength at elastic limit, per square inch).	Bending.		
Specific gravity.	Weight per cubic foot.		Fiber stress at elastic limit per square inch.	Modulus of rupture per square inch.	Modulus of elasticity per square inch.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*1,000 lbs.*
0.58	36.2	7,860	9,000	8,480	1,774
.55	34.4	6,510	6,920	8,120	1,355
.52	32.5	7,290	8,730	11,350	1,734
.51	31.9	6,270	6,490	7,540	1,173
.50	31.2	6,100	6,470	8,160	1,173
.49	30.6	7,660	8,380	9,710	1,786
.48	30.0	7,170	7,770	9,350	1,275
.47	29.4	6,890	7,230	8,880	1,163
.46	28.8	7,740	7,670	10,370	1,768
.45	28.1	6,070	6,550	8,180	1,406
.44	27.5	6,760	7,710	8,900	1,660
.43	26.9	5,470	5,000	6,240	892
.42	26.2	5,520	5,990	7,030	1,075
.39	24.4	5,200	4,900	5,750	841
.37	23.1	4,770	5,120	6,210	996
.35	21.9	6,070	6,550	6,250	925

[1] Forest Service Circular 19.

DURABILITY.

The great durability of the heartwood, probably more than any other property, gives cypress the place of distinction which it holds among the more valuable woods on the market. In contact with the soil or exposed freely to water or atmospheric conditions the heartwood ordinarily resists for many years the agencies of decay, while the sapwood under the same conditions is comparatively short-lived. Instances of cypress shingles [1] lasting 50 to 100 years, fences in good condition after 40 years, old plantation buildings in the warm, humid Southern States in excellent preservation after 100 to 200 years,[2] and others of a like character are frequently reported.

As the result of tests under way the Forest Service will be able later to furnish information in regard to whatever relationship may exist between color, oil content, and durability. The amount of oil or resin content in the wood varies considerably and is judged by the soapy feeling, which is somewhat characteristic and aids in identifying cypress. The name "cypressene" has been applied by some to this resin.

Cypress, like most other woods, is not entirely uniform in respect to durability. In fence lines some posts have to be replaced sooner than others; in boats some planks decay while others last almost indefinitely. In old cuttings the flat tops of large stumps are observed to vary in soundness although of exactly the same age. The seasoned heartwood when exposed to the weather appears to wear out by the mechanical action of water and atmosphere before it gives way through decay. Pecky cypress, although mechanically weaker than sound cypress in proportion to its bulk or mass, is very durable. The fungus producing the pecky wood is not known to cause any further injury after the tree is cut.

MOISTURE AND SEASONING.

The water content of living cypress is variable, and in the lower part of the trunk quite large in amount. Green cypress logs are nearly double the weight of air-seasoned wood. In logging operations trees are girdled in advance of felling in order to increase their buoyancy. (See p. 12.) The prevailing belief is that green cypress contains more water and dries at a slower rate than other kinds of "softwoods." Experience has shown that cypress is a rather difficult wood to season, both in the air and in the dry kiln, with a tendency to caseharden in the latter method. Preliminary experiments indicate that, in kiln drying, cypress requires a length of time more nearly like the hardwoods than the conifers. There is little doubt that cypress wood can be successfully dried when properly handled.

[1] The split or riven shingle known variously as "boards," "shakes," "shingles," etc.
[2] Mulberry Castle, on the Cooper River, S. C., built in 1714.

At present, however, purchasers largely specify against dry-kiln and in favor of long-period air-seasoned lumber.

Cypress shrinks about 8 to 10 per cent in volume,[1] and in this respect is intermediate between the light and heavy pines.

USES.

Cypress has a great variety of uses, and for many of these it is selected as a preferred material. The key to its usefulness is its resistance to decay and other forms of deterioration when in contact with moisture, and its quality of being easily worked. It is used extensively for outside finish of buildings, such as siding, casing, sashes, doors and blinds, cornice, railings, steps and porch material. As a gutter stock, cypress outlasts many other materials and is in favor for high-grade work. Standard planing products consume large quantities of cypress. These include ceiling, siding, flooring, molding, and finish. On account of its freedom from taste and great durability it is a preferred material for tanks, vats, tubs, and wooden buckets. These are used for water storage, and by creameries, breweries, bakeries, dye works, distilleries, and soap and starch factories. In the construction of greenhouses, where wood is subjected to extremes of heat and moisture, cypress is used probably more than any other wood. It is also a leading wood for pumps, laundry appliances, caskets, and coffins. Cypress is extensively used throughout the South in the construction of picket fences, which there remain the standard form of yard fence. In the moist, hot climate of the South, split cypress shingles have outlasted all other roofing materials commonly used, except the best grade of slate and tiles. While the ordinary sawed shingle is very durable, the relatively high value of cypress wood has resulted in cedar taking the lead as shingle material.

More than two-thirds of the total cypress-lumber output, estimated in round figures at 740,000,000 board feet in 1914, is further manufactured and utilized by the wood-manufacturing industries in the United States. The reports for 1911 show that 68 per cent (668,353,342 board feet) of the amount cut in that year was so used by these industries.[2] The balance of the lumber cut goes into general use in the retail market.

Relatively small amounts of cypress go into the primary products other than lumber. In 1911 the electric and steam railroads purchased cypress crossties to the number of approximately 5,800,000 or about 4.3 per cent of the total for the year.[3] Only 72,995 cypress poles were reported purchased in 1911 by all the principal classes of

[1] See Forest Service Circular 19, pp. 10–11, for earlier experiments in drying cypress wood.

[2] Taking the year 1911 as an average year for figures collected from the wood-using industries in the period 1910 to 1912, inclusive.

[3] Includes large numbers of ties from pecky hearts and hewed small-pole timber. Figures for 1911 are latest available for ties, poles, and cooperage.

pole consumers. Small amounts go into cross arms. A little is used for slack cooperage, and, experimentally, cypress has been found to be a substitute for white oak for wine barrels.

Large quantities of pecky cypress, which is relatively cheap, are used where good appearance and water-tightness are not required.

CYPRESS LUMBERING.

Most of the early centers of cypress lumbering were located near the mouths of the larger southern rivers. This was due to the prevailing method of float logging during high water. Logging centers have since moved inland, to the great interior swamps and higher portions of the river swamps.

In the early days large amounts of the finest cypress were annually cut in trespass and floated away. Standing timber was considered of so little value that State authorities and, to a less extent, private owners made little attempt to stop illegal cutting. Under the swamp-land act of September 28, 1850, very much of the swamp and delta lands early passed into the hands of the various States. Later these lands were sold very cheaply to railroads, timber companies, and settlers, in order to encourage the development of the country. The cypress industry has gradually become concentrated in a few hands.

Methods of logging and general mill equipment are essentially similar throughout the South. Various hardwoods, including tupelo gum as the latest addition, are now manufactured to a considerable extent by the cypress mills. Many large mills, however, are cutting only cypress.

LOGGING.

The present logging of cypress is attended by difficulties of a kind unknown in handling any other commercial timber. The bulk of all cypress is now logged by massive steam machinery moved from place to place on railroads built into the deepest parts of swamps over soft and treacherous ground. Periods of high water interfere with both the cutting and the moving of logs. For many years only the timber accessible to streams subject to flooding was taken. The soft nature of the soil and the great weight of the logs made it impossible to move the timber by the usual method—with oxen or mules. The wealth of cypress remained practically untouched until late in the eighties, although a few mills were operating earlier. The decline of the eastern white-pine industry sent into the South lumbermen who solved the difficult problem of logging cypress. Logging progressed from the float method in the eighties to the pull boat in the nineties, and from that to overhead-cableway skidding, the method now in use. (See Pl. I.)

Float logging consists of floating logs during periods of high water through "trails" and "float roads" previously opened in the forest.

The trees are girdled several months in advance of logging. The pull boat, as finally developed, with its stationary engine mounted on a float or barge, skids the cypress over the soft surface for distances up to 2,000 feet or more on either side of the canal or bayou. The dredge boat, working just in advance of the pull boat in digging canals in the swamp soils, gave access to the cypress where natural channels were lacking. The advent of railroad swamp logging with the overhead cableway skidder was the principal factor in opening up vast regions of cypress previously considered inaccessible because not sufficiently inundated. The light skidding engine, mounted on runners and pulling itself over the flat pine woods along the margin of swamps and known as a "snaker," has been a valuable accessory, especially in the Atlantic coastal region.

In the overhead-skidder method the logs are brought in by a carriage or "bicycle" traveling over a powerful cable suspended between the "head tree" and "tail tree," usually 600 feet apart (Pl. I). In the heavier types, such as the duplex-spar skidder, the total distance covered is 2,000 feet in the two opposite directions from the skidder engine, which rests temporarily on piles driven beside the railroad track. The logs are pulled up to the main cableway for distances of as much as 100 feet on either side. Thus a strip 2,000 feet by 200 feet wide, or approximately 9 acres, is covered at each "set." The smaller overhead steam skidder logs at each "set" successively a dozen or more strips 600 feet long extending outward as radii from the engine at the center, covering an area of about 26 acres.

The cost of logging is discussed on page 15 in connection with the total cost of lumber production.

GIRDLING.

It is the general practice to girdle or "belt" cypress trees from 6 months to a year in advance of logging. The result is that about 95 per cent of the logs will float instead of 10 to 20 per cent. This reduction in the number of "sinkers" is a matter of the greatest significance in cheap water logging and pond storage at the mill. Large operators, having considerable amounts of the more valuable hardwoods in mixture, generally use dry log yards instead of log ponds at their mills. In this case the cypress is not girdled.

Under direction of a foreman, girdling crews composed of 2 to 6 men each girdle the trees for a price per tree, usually from 6 to 9 cents, determined in advance by the general size and density of the timber. In order to secure early drying it is necessary in girdling to cut through the sapwood to the heart.

Among operators much variation prevails in respect to the season of the year chosen for girdling and the length of time before cutting. The majority prefer to girdle in the fall because the trees' activities

FIG. 1.—MATURE CYPRESS, 128 FEET HIGH BY 46 INCHES IN DIAMETER, SHOWING CLEAN TRUNK AND FORM OF MATURE CROWN. (GEORGIA.)

FIG. 2.—LOGGING IN DEEP SWAMP WITH OVERHEAD CABLEWAY SKIDDER AND RAILROAD. (LOUISIANA.)

FIG. 1.—DREDGE BOAT IN CLOSELY LOGGED CYPRESS. NO SEED TREES LEFT AMONG THE MASS OF HEAVY STUMPS AND ROOTS. (LOUISIANA.)

FIG. 2.—WASTEFUL LOGGING BY LEAVING VERY LARGE TOPS AND OFTEN HIGH STUMPS. SEED TREES, HOWEVER, WERE LEFT. (GEORGIA.)

TWO METHODS OF LOGGING CYPRESS.

are then at a low point and because that season is usually the driest in the swamps. Some choose the period following the spring high-water stage. An important influencing factor is the danger of attack by the pinhole borer or ambrosia beetle. For a discussion of this subject, based upon extensive investigations conducted by specialists, the reader is referred to Circular 82, "Pinhole Injury to Girdled Cypress in the South Atlantic and Gulf States," and Circular 128, "Insect Injuries to Forest Products," issued by the Bureau of Entomology, United States Department of Agriculture.

WASTE IN LOGGING.

Various forms of waste in logging are found in some regions. Utilization is complete, however, in the most literal sense of the term, among the Mississippi River operators; as a rule not a living cypress tree is left, stumps are cut low, and top logs are taken. Where clean cutting is practiced trees above 16 to 18 inches at the stump are taken for lumber; from 8 to 14 inches for ties, piling, etc.; and practically everything left by the axe is broken by the steam logger. Over the Atlantic region the wood in the trees felled has in the past been utilized much less thoroughly, and the smaller sized trees left standing. One company in western Florida commendably adheres to a high diameter limit in the selection of trees for felling, but wastefully cuts high stumps and leaves large top logs. As thousands of deadhead logs, or "sinkers," left 10 to 20 years ago, are now being taken out by machinery, so in turn later cutters on the same areas will undoubtedly pick up many large top logs and material left in high stumps. Although present cutting may be for special sizes and grades of stock, it is doubtful if it is wise or practical thus to leave large quantities of good timber in the woods (Pl. II). The high stumps often result from sawyers working in the girdle line, which, of course, is chopped out by the girdlers at as high a point as possible above the basal swell in order to avoid unnecessary labor.

Waste in logging cypress is generally attributed to the poor quality of labor, but is usually due to carelessness in supervision and failure to realize the true stumpage value of the material left. Operators on the Atlantic coast, where freight rates to the larger markets are considerably lower, should be able to apply to their own logging the methods which have been worked out so successfully in Louisiana. In many cuttings in the Atlantic coast region stumps are left 5 to 9 feet high in order to effect a slight saving in labor; while in Louisiana, as a general practice, small trees are cut at 2 feet, and all others, up to the largest sizes, at 3 feet. The amount of merchantable lumber contained in the upper 2-foot section of a stump 4 feet in diameter cut 5 feet in height, allowing 35 per cent for defect and not including the slab, is 90 board feet. At a stumpage rate of $8 per thousand

feet, the value of the short-log section left is $0.64, or about 15 cents more than is paid on an average for felling and cutting the trees where the cypress runs good size. The wood left in a similar stump 3 feet in diameter at the top gives a waste of about 33 cents per tree. If operators would spend a few minutes in figuring the total value of the timber left in stumps above a 3-foot maximum many would, in all likelihood, revise their system of cutting.

MILLING.

Large-sized mills are the rule in the cypress industry. Many mills average daily runs of from 80,000 to 100,000 board feet. The larger mills in Florida and Louisiana turn out on an average up to 200,000 feet daily, and a few cut as much as 275,000 feet by using two double-cutter band mills and resaws. With the exception of a few inland swamp districts, the majority of cypress mills are located with reference to convenience in the transportation of either logs or lumber, or both, by water. Logs are rafted to the mill through lakes, bayous, and sometimes artificial canals, for distances of from 50 to 125 miles. The typical mill is equipped with a double band saw, shingle and lath mills, up-to-date planing mill, dry kilns, and a lumber yard of unusually large size. Nearly all use pond storage, and many have complete dry-log yard equipment in addition as a provision against irregularities in girdling and logging during extended high-water periods. Ordinary labor is usually paid for by the day, and the more expert by the month or year. In the highest form of organized manufacture the entire manufacturing operation from the standing tree to the loaded car, with a few minor exceptions, is done under contract at a stipulated price per 1,000 feet.

WASTE IN MILLING.

In mill practice, complete utilization is the rule rather than the exception. The products of the ordinary mill are lumber, lath, and shingles, and a great variety of planing-mill products. The refuse burner gets little of the sound timber except small trimmings and sawdust, but a good deal of trash in advanced stages of decay. Because of the large number of standard short lengths and the strong demand, slabs are worked closely for lumber, and the remainder is sent along with the trimmings into the secondary mills, producing shingles, lath, pickets, etc. In younger cypress, where the butt swell is prominent, butt logs furnish a large amount of such material, and all is in excess of the log scale. Pieces down to 4 inches in width by 12 inches in length are utilized for tubs, buckets, washing machines, etc. Planing-mill orders include a great variety of small sizes for special uses in contact with water. There is still opportunity for considerable improvement in the utilization of small-sized waste on the part of many operators in cypress.

COST OF MANUFACTURE.

The investment required in the manufacture of cypress lumber is considerably higher than for most kinds of timber. The essential factor is the high initial cost of logs delivered at the mill. Briefly, the high expense of manufacture is due to:

(1) The costliness of the equipment required for logging.

(2) Cypress is mostly cut into 1-inch lumber, and very little goes into dimension stock, as is the case with the southern pines.

(3) The stock is usually held from 8 months to a year, and sometimes for 2 years, in order to permit of thorough air-seasoning. This entails large holding charges.

On the other hand, cypress forests are in the lowest situations, affording water transportation in many cases for logging and in some cases for shipping lumber. Float logging, the method of the earlier days, was relatively cheap. In Louisiana the timber lies so far from the water fronts and places where artificial canals are practicable that pull-boat logging is said now to average from $1 to $3 more per 1,000 board feet than overhead-cableway skidding and swamp railroads. The fire danger, with the necessity of clearing rights of way and of slash disposal, is eliminated in cypress logging.

Logging railroads are built on piling over swamps at costs ranging from $9,000 to $12,000 per mile, and sometimes $15,000 for main lines. Temporary logging spurs on mud piles, cribbing, or sawdust beds cost from $1,000 to $2,000 per mile. The usual equipment consists of locomotives and cars, in addition to the combined skidders and loaders for getting the logs from the stump to the car. The climax of logging machinery, the 135-ton duplex spar skidder in use on the Santee River, S. C., and perhaps elsewhere, costs approximately $28,000 set up and ready for operation. Water logging by steam requires heavy dredge boats for digging canals, pull boats equipped with skidding engines and tons of steel cable, and towboats for getting the logs to the mill. Frequently logging is done by a combination of both methods. In order to avoid undesirable shutdowns, the logging capacity of cypress plants is large in relation to the mill capacity.

The cost of manufacturing cypress is subject to very wide variation, due mainly to the different conditions in logging and the varying soundness of the timber. In the older supply regions costs often run nearly double those in the more virgin districts. The figures below will indicate the general range of cost in complete manufacture:

Logging:	Cost per 1,000 board feet.
Girdling (price per tree, 8 to 12 cents)	$0.15 to $0.20
Cutting (paid by the tree or thousand board feet)	.60 .80
Skidding and loading	1.95 2.90

Logging—Continued.	Cost per 1,000 board feet.
Railroading	$2.10 to $3.10
Depreciation and overhead charge	.70 1.00
	5.50 8.00
Milling:	
Sawing	1.95 to 3.00
Yarding	1.85 2.50
Depreciation and overhead charge	.95 1.50
	4.75 7.00
Total	10.25 to 15.00

The lesser figure for total cost will appear low for smaller operations in scattered cypress along the Atlantic coast, where complete manufacture costs from $13 to $16. In the large tracts of the Mississippi delta, with heavy yields per acre on relatively stable soils and large-scale operations, the cost averages from $9 to $13 per thousand. Logging is more expensive than milling by from $1 to $3, and milling averages from $5 to $7 per thousand feet, because of the large amount of defective or pecky material, close utilization, and small sizes run through the mill. In Louisiana, where the larger companies pay for practically every operation of manufacture by the thousand feet, lumber is produced at the lowest average cost.

GRADES.

Cypress is manufactured and handled in the trade under detailed and very satisfactory inspection rules. The grading rules adopted by the Southern Cypress Manufacturers' Association,[1] composed of about 50 producing companies, are in most general use. Their seven major grades and great number of finish grades are well defined and allow of a marked uniformity. Odd as well as even lengths above 4 feet have been for some years standard, with certain limitations as to the proportional amount of odd lengths. The major grades are tank stock, first and second clear, selects, shop (two grades), selected common tank stock, barn or dimension (two grades), cull or peck. The National Hardwood Lumber Association and the Hardwood Manufacturers' Association both use the rules of the Southern Cypress Manufacturers' Association.

At the saw there has been a gradual decline in the average quality of the lumber, due chiefly to logging in situations less favorable for growth, in tracts formerly culled of the best trees, and closer utilization. Records kept continuously for the past 5 or 10 years show a marked decline in the percentage of clears and selects, and corresponding increases in shop, and especially common.

[1] Mr. George E. Watson, Secretary, Hibernia Bank Building, New Orleans, La.

The seven grades of the Southern Cypress Manufacturers' Association give the following averages in a number of representative localities, with 5 to 15 years' cut in the future: Tank, 2 per cent; clears, 15; select, 16; shop, 19; barn, dimension, and boxing, 27; peck, 9; ties, posts, and miscellaneous, 14 per cent.

STOCK AND SEASONING.

The great bulk of cypress is air-dried for periods of from 9 to 12 months. A representative mill in Louisiana, carrying about 45,000,000 feet of cypress in its yards, kiln-dried only 2 per cent of its lumber, but 60 per cent of its shingles and lath. Tank stock 3 inches thick should have about 18 months for air-seasoning. Except in an emergency, little of the high grades is run through the kiln, since checks and raised grain often appear, but some mills kiln-dry the commons, and so hasten their disposal. Because of the large water content, green cypress shingles are very heavy. Kiln drying effects a reduction in weight of about one-half. For doors and other high-grade products, manufacturers call for lumber dried for from 10 to 16 months, followed by kiln drying for from 3 to 20 days. Close mill utilization and the demand of the trade for air-seasoned cypress in a very large assortment of sizes and forms are the reasons why cypress mills carry a very much larger stock than mills of equal capacity operating in most other woods. Such large stocks are not turned over rapidly, and mills usually carry some lumber 2 or 3 years. The durability of cypress and its freedom from bluing and other injury affecting most woods account for the prevalence and entire success of open-air seasoning and slow handling of the stock.

MARKETS AND LUMBER PRICES.

Cypress was for a long time a little-known wood, used for the most part locally in the manufacture of shingles. It made but slow progress in the general market, and was subject to frequent fluctuations, which were annoying and costly to operators with capital tied up in standing timber and manufacturing plants. Now it has come into national prominence and there is a strong domestic demand for it. Although the larger part of the entire cypress cut is marketed in the region east of the Mississippi and north of the Ohio River, users and manufacturers in the Central and the Middle Western States are realizing more and more the value of cypress for certain purposes. The redwood of the Pacific coast has been to some extent a competitor of cypress, and cheap transportation through the Panama Canal may perhaps bring it into the eastern markets in larger quantities.

In 1914 the average mill-run price of cypress in Louisiana was about $23.50 per thousand feet.[1] It is interesting to note that during the 12-year period following 1900 the price of northern white pine increased by $6.44 and that of cypress by $6.77. Cypress for many years has led all other conifers or "softwoods" in the average mill-run of its product. In 1899 cypress was 63 cents ahead of northern white pine, its nearest competitor; in 1907, $2.61 ahead; and in 1914,[1] it led by about $4.40.[2] Pecky cypress, for which there is a good market, usually brings the millmen $8 to $10 per thousand; commons, from $10 to $20; shop, $20 to $25; selects, $28 to $35; and clears, $35 to $45. These are round figures, but suffice to show the range of values. The cost of cypress to the wood-manufacturing industries throughout the United States, during the period of 1910 to 1912, averaged about $26.95 per thousand board feet f. o. b. cars at the factory.

STUMPAGE.

In the early years of the cypress industry practical lumbermen with business foresight began to accumulate cypress holdings, which were then popularly considered of small value. The flat swamps in which cypress flourishes seemed to offer insurmountable obstacles to cutting and getting out the timber to a point where it could be manufactured into merchantable products. Along streams subject to high spring floods the situation was more favorable. Pine lands were still relatively cheap; and cypress swamps, on account of their accredited inaccessibility, were looked upon by the settlers as of little value. Large tracts of overflow lands in Louisiana and Florida acquired by speculators for 25 cents up to $1 per acre, are now worth from $70 to $125 for the standing cypress alone, and are not really available at that price.

Stumpage values of cypress have become quite uniform, no doubt on account of the relatively few hands in which the remaining supplies are held. Along the Atlantic coast, where the bodies of cypress average smaller than in Louisiana and Florida, somewhat lower stumpage prevails. The cost of production, however, is relatively greater, but is offset a little by the shorter distance to the northeastern markets and also influenced somewhat by the lower intrinsic land values in the region. A stumpage value averaging about $8 per thousand feet is quoted for much of the best cypress throughout the Gulf region. This decreases in Florida and up the Atlantic coast to a more representative value of $6 to $7 per thousand for good

[1] Based upon 14 special reports to the Forest Service of average prices during 1914 from 5 of the larger mills in Louisiana. This is doubtless higher than for the whole cypress region. Figures for 1899 and 1907 are based upon Bureau of Census reports.

[2] The average price of northern white pine for 1914 was $19.13, based on 27 reports during year from 8 large mills in Minnesota and Wisconsin; special reports to the Forest Service.

tracts of cypress timber. Seven sales in Louisiana in 1914, aggregating 45,000,000 feet were made at prices reported as ranging mostly from $3.50 to $8.25, but reaching nearly as low as $2 per thousand feet, probably by reason of some condition such as scattering or inaccessible stands. Over 270,000,000 feet in Florida, comprised in four tracts, sold in 1913 at prices reported as ranging mostly around $3 and $3.50 per thousand feet. Assuming an average cost of manufacture of $13 and a legitimate profit of $2.90 per thousand feet, on the basis of the average mill-run price in Louisiana in 1914, the operator is realizing $7.63 on his stumpage. A lower quality of standing timber, increased cost of manufacture, and lower average mill-run values will bring the returns from stumpage down to averages estimated mostly at $3.50 to $5.50 per thousand. It is apparent that at the present lumber prices, even with the upward tendency in cost of manufacture, prospective operators can afford to pay $6 to $8 for good cypress stumpage and make a reasonably good net profit.

LIFE HISTORY OF THE TREE.

Cypress is a tree of ancient lineage. Forest remains show that, prior to the glacial period, cypress, along with the redwood, incense cedar, the ginkgo (now of China), and several hardwoods, grew in abundance in the Arctic regions of both North America and Europe.[1] By subsequent climatic changes these species were driven southward along widely separated lines. The ginkgo descended the coast of China, the redwood the western coast of North America, and cypress the eastern coast to the warm south Atlantic and Gulf regions.

BOTANICAL FORMS.

Among botanists at least two forms of cypress are commonly recognized. These two forms overlap in geographical range and intergrade to such an extent that it is often difficult and sometimes impossible to distinguish between them. The differences, moreover, become less apparent as the tree increases in age.

When found distinct, the main form is characterized by flat leaves arranged in two ranks along the horizontal branchlets, wide-spreading limbs, and thin, comparatively smooth bark. The most common type of the other form (*Taxodium distichum* var. *imbricarium* Sarg.)[2] is distinguished by its small, asicular or appressed leaves, smaller and more ascending branches and branchlets, and thick, strongly furrowed bark (Pl. X). More recent investigation has added to the above some minor characteristics of the wood and differences in rate of growth, which are discussed elsewhere under appropriate

[1] Shaler, N. S., Memoirs of the Museum of Comparative Zoology, Harvard University, Vol. XVI, No. 1.
[2] Variously held among botanists to be a variety or distinctive species.

headings. Each of the two forms, however, within itself presents real variations in leaf, branch, bark, and wood.

There are indications that the varietal form (var. *imbricarium*), which is more abundant over the Atlantic Coastal Plain than elsewhere, is undergoing a gradual botanical segregation during its assumed northward migration from Florida, and has been since the close of the glacial period. Progress in segregation is necessarily slow on account of the heaviness of the seed and its exacting moisture requirements for successful germination. Evidence points clearly to soil conditions, particularly acidity and drainage, as fundamental factors causing the botanical variation of cypress. The range of the imbricate form, so far as at present known, is generally coincident with the limits of the Atlantic Coastal Plain, but extends southward into northern Florida and westward to Alabama. The main species, on the other hand, finds its most congenial home along the Gulf Coast and up the Mississippi Valley in the deep alluvial soils.

OCCURRENCE.

The close restriction of cypress to very wet situations suggest two explanations: (1) That the species requires much water and is in reality a semiaquatic or mud-inhabiting species, or (2) that it has been forced to these unfavorable situations because of inability to compete with species better adapted to occupy the more favorable uplands.

Close observations on young cypress agree in furnishing evidence that, in its early stages, cypress is very exacting and successfully establishes itself only in situations of very abundant moisture. Subsequently, however, seedling growth is noticeably more rapid on better drained situations. These observations lead to the conclusion that in extremely wet situations cypress, in a greater or less degree, is tolerating conditions not generally favorable to the normal thrifty growth and development of the tree. In other words, the inherent soil and moisture requirements of cypress after its earliest stages are to be looked upon as very similar to those of many of the hardwood timber trees which thrive best in a deep, loose, well-drained, fresh, rich, sandy or clayey loam, containing humus and available mineral food, and well supplied with soil moisture.

Broadly speaking from a geological standpoint, cypress therefore belongs characteristically to young lands. Cypress is the dominating tree in the forests of the alluvial lands of the South. It advances slowly, but ahead of all other trees, as river and sea marshes gradually build up, flourishes in the deep alluvial soils submerged for a portion of the year, and later is driven out by the competition of hardwoods as the lands are further built up and become drained.

Within its natural geographic range, cypress occurs locally on quite widely different situations, all alike, however, in their swampy character. These may be grouped broadly under four classes, differing chiefly in the amount and acidity of the water, and, to some degree, in the composition and texture of the soil.

ALLUVIAL SWAMPS.

Swamps traversed by rivers or creeks which fluctuate in height and carry considerable solid matter in suspension are classed as alluvial river swamps. The overflow lands of the lower Mississippi River are among the richest and deepest alluvial soils in the world. Other alluvial streams are the Peedee, Santee, Savannah, Apalachicola, and Mobile Rivers. Broad river deltas or estuarine swamps, occurring at the mouths of some of these, take the form of an intricate net work of narrow channels. The water is always more or less muddy, but because of its breadth and its closeness to sea level is subject to only slight seasonal fluctuations. During the summer and fall the water in these swamps becomes stagnant and because of its acidity is rather unfavorable to tree growth. The continuous saturation of the soil and relatively slight fluctuation in depth of water are favorable to cypress seed germination.

Cypress reigns supreme over extensive areas of the flat delta region of the lower Mississippi. The bayou or river is bordered on both sides by a natural levee, back of which comes a succession of sloughs and low ridges leading into a deep swamp often miles in width. Over the ridges cypress gives way to oaks, red gum, ash, red maple, honey locust, hackberry, and a few less important hardwoods. The two forest types are represented graphically in figure 2, showing cypress confined mostly to permanently wet situations. Heavy cypress stands or "brakes" occupy the shallow lagoons and cut-offs of former river channels. Farther upstream the swamps of the large alluvial rivers are closely bordered by uplands which confine the water, causing deep inundation. Their surface is undulating and subject to complete overflow only during periods of high water. As a rule these swamps are better drained and, superficially at least, dry during most of the growing season. Growth is good and the quality of the timber produced is excellent.

NONALLUVIAL SWAMPS.

These swamps are located at or near the heads of watercourses and along clear-water streams, fed mostly by seepage and springs. They have dark or coffee-colored but clear water and muck or peat soils. The Dismal and Okefinokee Swamps (fig. 3) and many river swamps in Florida are typical of this class, and the water carries little sedi-

ment even during the flood season. Black gum and the bays in muck soils and southern white cedar in the peat soils are the main associates of cypress.

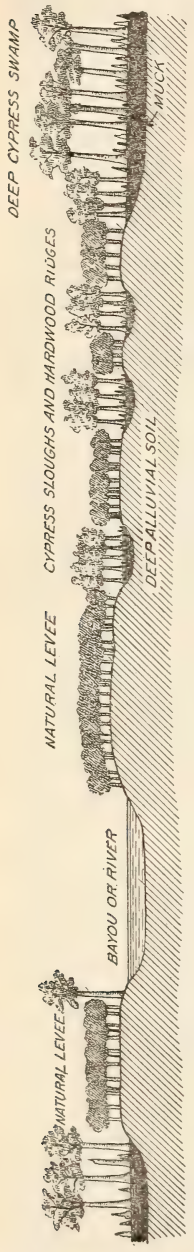


FIG. 2.—Section of Grand River (Louisiana) showing hardwood ridges, cypress sloughs or glades, and deep cypress swamp. (Vertical scale exaggerated.)

PINE BARREN "POND" SWAMPS.

The effect of variable moisture supply and highly acid soil is seen in the stunted and rather defective stands of cypress occurring in the ponds distributed thickly over the region from South Carolina to Florida. Here the starved cypress in its extreme form occurs and is commonly known as the "pond" cypress. In these situations cypress has practically no competitor, although there is some scattered water gum, and, near the margin, Cuban pine, pond pine, and spruce pine.

COASTAL SWAMPS.

While cypress is a tree tolerant chiefly of fresh water, it reaches the coast and advances a little into brackish tidal water. Growth here is distinctly inferior, and the salty overflow during driving storms undoubtedly accounts for the early death of many trees. The tree is an inhabitant of the fresh-water wooded swamps in distinction from the open grassy everglades and "prairies" of fresh water on the one hand and the coastal marshes and salt-water mangrove swamps on the other. Many of the cypress "brakes" or cut-off sloughs represent the gradual filling of marshes and lagoons, which in a previous geo-

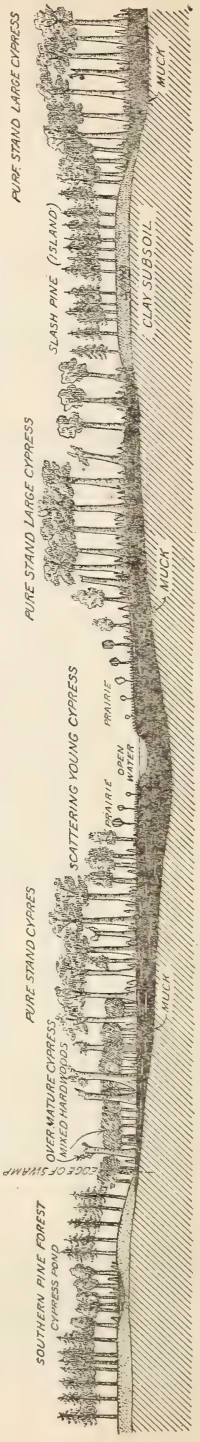


FIG. 3.—Section of Okefinokee Swamp (Georgia) showing open water, prairie, and various stages of young and old cypress stands. (Vertical scale exaggerated.)

logical period, as arms and bays of the ocean, extended far into what is now the Coastal Plain and great central valley.

LONGEVITY.

Cypress attains so great an age that the life periods of virgin stands are better spoken of in terms of centuries than of decades. Trees from 400 to 600 years old are very common, and those from 600 to 900 years are scattered through most virgin cypress stands. Individual trees 750, 820, and 845 years old were noted in the Okefinokee Swamp, 915 years in southern Louisiana, and about 1,200 years in the Flint River in southwestern Georgia.[1] Roth determined the age of a cypress near the Santee River in South Carolina [2] as over 1,200 years. There is considerable evidence that the greatest ages are reached in the region from South Carolina to northern Florida in the nonalluvial and slightly acid swamps subject to only slight differences in water level. The age attained seems to be limited chiefly by the ability of the tree to resist the attacks of fungi and force of the wind. Old trees die backward or downward during a period usually of one to three or four centuries. The last stage is usually a hollow cylinder consisting of sapwood from which the heart has been removed by decay (Pl. III). It is not improbable that the ages of these hollow veteran cypresses range from 1,000 to 2,000 years.

SIZE.

The prevailing size of mature trees in ordinary situations is somewhere about 3 to 5 feet in diameter at breastheight (4½ feet above the ground) by from 100 to 120 feet in height. In the highly acid soils of ponds and poorly drained, flat swamps the average maximum size is about 2 feet in diameter by from 50 to 70 feet in height. The largest trees scattered on ordinary sites are 7 to 8 feet in diameter.[3] The maximum diameter for cypress is about 12 feet measured at breastheight. Maximum heights of from 140 to 150 feet are occasionally reached.[4] In all cases, however, the culmination in height comes from one to four centuries earlier than the greatest diameter. The trunks of the trees of largest diameters are usually hollow at the base and more or less broken at the top.

FORM.

In form, cypress is a tall, straight-stemmed tree (Pl. I). In regions of prolonged inundations the tree usually develops a high,

[1] Ages very similar to the coast redwood of California, *Sequoia sempervirens* Endl.
[2] Forest Service Circular 19, p. 3.
[3] See also discussion of volume on p. 41.
[4] Sargent, C. S., "Manual of the Trees of North America," p. 72.

sometimes remarkably wide, buttressed or ridged base. Toward maturity this form at the base gradually disappears as a result of change in growth toward a cylindrical or columnar form. Another cause is geological in character. The remaining basal swell becomes buried during the course of several centuries by alluvial and peaty deposits, often to a depth of from 3 to 5 feet. In swamps not subject to high floods cypress usually has only slight basal swell (fig. 4). The narrowly pyramidal and symmetrical crown of smaller branches during earlier life gives way gradually during the second and third centuries to a broad, flat-topped crown consisting of a few wide-spreading, heavy limbs. This form persists during from two to four centuries; then decay, accompanied by winds, usually carries away considerable of the original top (Pl. III). In the open, cypress maintains a full crown of many small branches more cylindrical in form and very much less dense than the eastern red cedar.

BARK.

The bark shows extreme variation from a thick, deeply furrowed fibrous bark to a thin scaly one. The tree is very responsive to physical environment. In Florida, for example, near fresh, deep water, the bark at all ages is very thin, soft-fibered, and light brown in color, while in adjacent situations with sluggish or stagnant water the bark is thick and of a reddish color, the heartwood is darker and somewhat heavier, and the sapwood thinner and more uniform in width (Pl. X). In the great Wilmington Swamp of North Carolina the bark is prevailingly thick and firm. During logging it breaks apart into long, stringy fibers of a rich brownish-red color. The difference in bark thickness ranges mostly from $\frac{1}{4}$ to $1\frac{1}{2}$ inches. All intermediate gradations are present, and when the two extremes appear in the same region they are accompanied by different conditions of soil and moisture.

LEAVES.

The foliage consists of very small flat or needle-shaped leaves, arranged either in two ranks or closely appressed to fragile branchlets. Cypress is a conifer, but not an evergreen tree, and both leaves and branchlets are dropped in the fall. The wide variation in leaf form appears to be accompanied by corresponding differences in the amount and acidity of the water supply.

ROOT SYSTEM.

The conical base of cypress divides below the surface into about six to ten strong descending and spreading roots, which provide a deep anchorage for the tree. The form suggests that of a mushroom anchor. In addition to the descending roots, a number of large laterals extend outward near the surface like cables and form

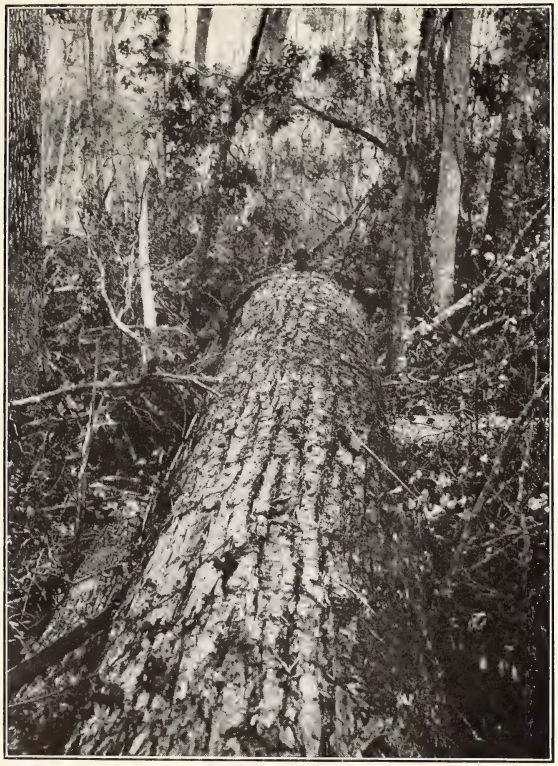


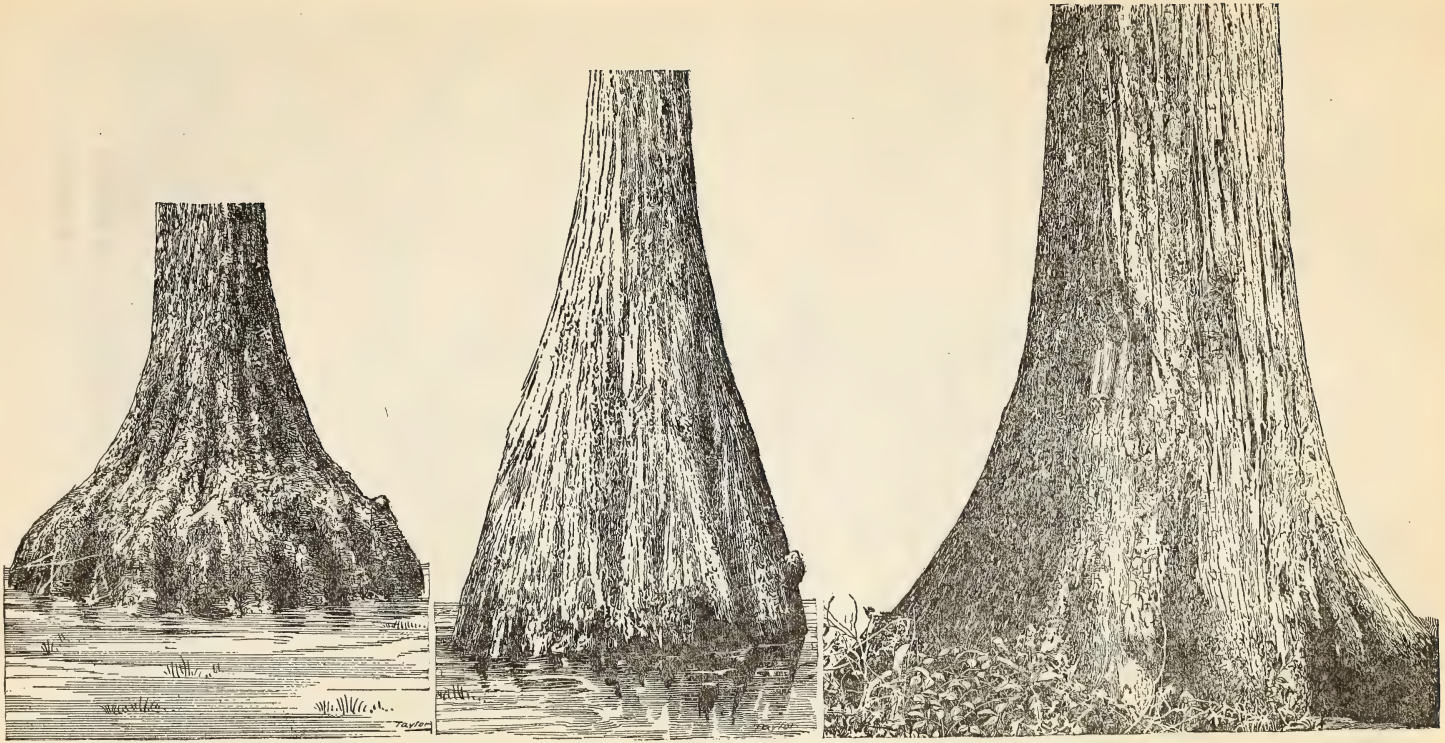
Fig. 1.—Cypress Mostly Sound at 670 Years Old, 60 Inches in Diameter. Note Rough Bark.

Fig. 2.—Numerous Sprouts on Hollow Stem of Overmature Veteran Cypress; Age About 900 Years.

MATURE AND OVERMATURE STAGES IN LIFE OF CYPRESS.

FIG. 1.—TYPICAL CYPRESS "POND" IN FLAT PINE WOODS, YIELDING POLES, TIES, AND SOME SAW TIMBER. IMPORTANT IN FUTURE MANAGEMENT OF SOUTHERN FORESTS. (GEORGIA.)

FIG. 2.—BASE OF 8-FOOT CYPRESS, ABOUT 1,200 YEARS OLD. (FLINT RIVER BASIN, GA.)



a. *b.* *c.*

FIG. 4.—Variation in the basal form of cypress (from photographs). *a*. Low, very broad base in shallow, nonalluvial wet swamps (South Carolina); *b*. High, full basal swell in active or fresh water subject to deep inundations (Florida); *c*. Small basal swell typical of broad overflow region of the lower Mississippi River, and large inland swamps (Okefinokee Swamp, Georgia).

the widely spreading and branching superficial root system that has been more commonly recognized. The masses of roots at the base of cypresses have proved such an expensive obstacle to the digging of canals through swamps as to cause the financial failure of numerous timber operations dependent upon this form of logging.

CYPRESS KNEES.

The peculiar cypress "knees," or upright conic portions of the superficial root system, are of unusual interest. Knees occur mostly where water covers the surface for long periods, and their height corresponds rather closely to the average high-water level for the locality. Occasionally they reach heights of from 8 to 10 feet above low-water mark. Observations indicate further that in soft or yielding situations the root system is much more extensive and the knees correspondingly larger than in firmer soils. They appear in general to be as common in alluvial as in nonalluvial swamps, and in fresh as in stagnant or acid soils. The wood is light in weight, but peculiarly gnarled and twisted in structure, and therefore of extreme toughness. Except in their early stages, the knees are usually hollow, and they commonly die at once when the tree is cut.

In regard to the function performed by cypress knees very little is known by actual experiment. Wilson,[1] in a series of carefully conducted laboratory tests with cypress seedlings, found that when continuously submerged in water the superficial roots sent branches upward to the surface. This suggested the function of knees as breathing organs for the roots. In speaking of adaptations in marsh plants, Warming [2] states that in some trees and shrubs erect roots are developed which thrust their tips above water and convey air to the root system beneath in the mud and water, and on the authority of Kearney cites cypress as an example. At its lower end the knee has a downward-reaching, pronged root system, smaller but very similar in form and appearance to the main root system beneath the tree.[3] The knee thus might be termed a sort of secondary tree, with the difference that it is composed of root wood. So far as is known there is no record of a knee budding or sprouting.[4] It clearly is not developed for the purpose of reproduction.[5]

Although commonly credited in literature with serving the function of aerating organs, there is no definite proof from mature trees of the part played by knees in the economy of the tree. An experiment

[1] Wilson, W. P., formerly of University of Pennsylvania. Proceedings Academy of Natural Science, Philadelphia, April, 1889; see also Forest Leaves, Vol. II, p. 100–111.

[2] Warming, Oecology of Plants, p. 186.

[3] Fig. 5 shows clearly this structure in trees photographed by Robert H. Lamborn. See Garden and Forest, Vol. III, p. 20.

[4] Seedlings are occasionally found growing from seed which lodged and germinated in the hollows of decaying knees.

[5] See "Effect of submergence," p. 38.

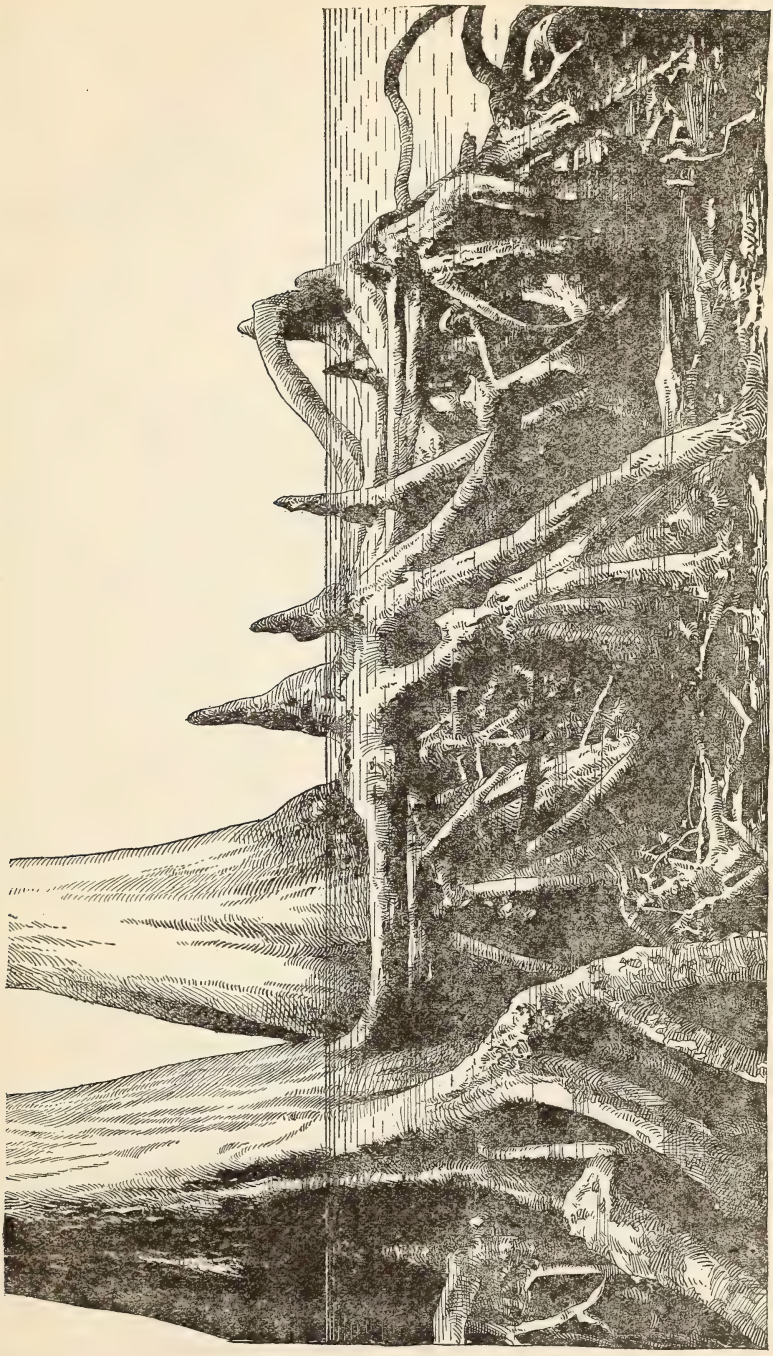


FIG. 5.—Cypress root system exposed 4 feet deep by wave action upon loose sandy soil following partial drainage of Lake Monroe, Fla.

has been started by the Forest Service in Louisiana to determine what effect the removal of the knees has upon the subsequent growth of the tree. The knees were removed from 15 trees and left on 5 near-by trees to serve as a check for later comparison. It should be noted that other swamp species, including tupelo gum, water ash, white bay, and others, do not produce knees, although they frequently occur in apparently the same situation where cypress has developed knees at least 2 to 5 feet in height. Some of the species do, however, develop slight humps or kinks in the surface roots.

Although cypress occurs chiefly on the most unstable and treacherous soils, it is one of the most windfirm of all southern commercial trees.[1] On what engineers would pronounce the most dangerous foundation it rears a shaft, often of massive proportions, for 60 to 90 feet in height, topped by a wide-spreading head of giant limbs with very numerous branchlets. It is obvious that the wind pressure at times upon a mature cypress is very great. However, Lamborn and Newberry,[2] both of whom traveled extensively in the southern regions, state that they do not recall having seen a living cypress overthrown by the wind. The great resistance offered by cypress to the force of wind is pointed out by Mohr,[3] who visited the path of the severe tropical hurricane of September, 1892, along the Savannah River in Hampton County, South Carolina. He states that "not a single cypress was seen to have yielded to the fury of the storm, although the pines in its track were mowed down like grain before the reaper, and the sturdy live oaks and laurel oaks were uprooted."

The mass of interwoven horizontal roots, with the aid of hundreds of vertical roots beneath the knees, binds the associated soil materials and furnishes a stable support for the weight of the tree. The large sustaining force of cypress roots is thoroughly recognized by lumbermen and is utilized in the construction of logging railroads over swamps.

The mechanical function of the knees was pointed out by Lamborn,[4] who investigated the subject from the standpoint of a mechanical engineer. In his conclusion he stated "that the most important function of the knees is to stiffen and strengthen the roots, in order that the great tree may anchor itself safely in a yielding material." Mohr in his thorough study of cypress reached the same conclusion.

In view of the requirements of cypress for an extraordinary root system for support in soft, yielding soils and the binding effect of the

[1] Elliot says: "The cypress resists the violence of our autumnal gales better than any other of our forest trees." Botany of South Carolina and Georgia, p. 643, 1824.

[2] Garden and Forest, Vol. III, p. 21.

[3] Mohr, Dr. Charles, Manuscript report on cypress, based upon an extensive field study. Forest Service, Department of Agriculture.

[4] Lamborn, Robert H. "The knees of bald cypress: A new explanation of their function." Garden and Forest, Vol. III, p. 21.

pronged and multiple roots below the knee, it appears very probable that the knees are developed not only for the purpose of increasing the supply of oxygen which the roots are able to obtain directly from the water, but of enlarging and strengthening the basal support. The evidence of this belief is (1) the general absence of knees in swamp soils superficially dry during most of the year, (2) the presence of knees where there is an excess of surface water for long periods, (3) the rise of the knees approximately to the height of the average flood level, and (4) the interwoven network of roots in the superficial root system, and the anchorage afforded by the mass of deep roots beneath the knees.

REPRODUCTION.

SEED AND GERMINATION.

Cypress has the power of reproducing itself both by seed and by sprouts from the stump.

Cypress cones ("balls") contain from 18 to 30 twisted, sharply keeled, or winged seeds[1] (Pl. XI). Large pockets or sacs in the cone are filled with an exceedingly sticky, red, liquid resin, unpleasant to the taste. This probably explains why the seeds are only in slight degree taken as food by either birds or rodents. The outer coating is thick and hard. When free from cone scales or other materials there are about 5,000 seeds per pound. Upon ripening in October and November, the seeds fall to the ground near the tree. Unlike the seeds of most conifers, cypress seeds are not scattered to any extent by wind and animals. Seed is borne in abundance. Some is produced almost every year, and full seed crops, so far as is known, occur at intervals of about every three years. Some of the seed is aborted or infertile, so that germination averages usually from 40 to 60 per cent.

Tests[2] of seed collected in the two Carolinas in the fall of 1913 gave from 55 to 65 per cent of germination (Table 5 and Pl. XI). The general average for seed from all sources is perhaps 40 to 50 per cent. Seeds stored indoors in a warm, dry room from November until the following April, 1913, gave 55 per cent germination, occurring mostly in five weeks and reaching completion in seven weeks. Some of the same lot after soaking in stagnant water in a warm room for six weeks gave 65 per cent germination, complete in two weeks from date of sowing. In another test seed which was kept continuously moist and aerated under a glass jar for a period of four months completed germination in seven days,[3] with a total of 87 per cent germination.

[1] Size of seed averages from ¼ to ¾ inch long by ⅛ to ¼ inch wide.

[2] Conducted by the writer in greenhouse flats at the Arlington Experiment Station, U. S. Department of Agriculture. The seed was collected at random from trees in North Carolina and South Carolina 50 to 100 years old, and conditions for the tests were practically ideal.

[3] In June, 1913.

TABLE 5.—*Germination of cypress seed* [1] *in greenhouse test, Arlington Experiment Station, U. S. Department of Agriculture.*

Date of examination (1914).	200 dry seeds sown on Apr. 3, 1914.		20 soaked seeds sown on May 9.[2]		50 moist seeds sown on May 16.[3]	
	Number.	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
Apr. 25.	13	6.5	.....	.....	.....	.....
Apr. 30.	46	23	.....	.....	.....	.....
May 6..	90	45	.....	.....	.....	.....
May 11.	100	50	.....	.....	.....	.....
May 16.	104	52	.....	.....	.....	.....
May 21.	107	53.5	8	40	.....	.....
May 23.	109	54.5	13	65	43	87.5
May 25.	111	55.5	13	65	43	87.5
May 30.	111	55.5	13	65	43	87.5

[1] Seeds collected in October and November, 1913, in North and South Carolina, and stored in warm, dry room.
[2] Seeds from lot as above, soaked in stagnant water 6 weeks prior to sowing.
[3] Seeds from same lot as above, kept in moisture-saturated air for 7 weeks prior to sowing.

Over the extreme northern part of the tree's range very little of the seed matures.[1] Germination takes place at various times during the following spring. If it is early the seedling is exposed in the swamp to the extreme vicissitudes of periods of high water. If the seed is kept continuously submerged, it will not germinate.

The seed-bed requirements are a very abundant supply of moisture maintained for a period of from one to three months. Under these conditions the hard seed coats swell and soften, allowing the tender seedling to emerge. The young seedling is thus almost semihydrophitic in its early stages and develops well in completely saturated soil, though it does even better where there is some drainage. A bed of sphagnum moss seems to afford the best kind of seed bed, doubtless because of its capacity for retaining moisture in large quantities. Soft, wet muck is also favorable to successful germination.

SPROUT REPRODUCTION.

Cypress sprouts freely from the stump under ordinary conditions during the first 50 to 100 years. Sprouting from stumps 100 to 200 years old is not unusual. A coppice sprout 6 feet high was seen in Louisiana growing from the top of a stump over 300 years old cut about 14 years ago at the height of 8 feet. All of the sapwood had decayed except beneath the sprout, where living connection with the root had been maintained. Large, thrifty coppice occasionally sprouts from stumps up to 180 years old. In every such case observed the parent tree was of slow growth and therefore relatively small (Pl. VI). Economic reproduction by sprouts is rather closely restricted by the age and size of the parent stump. Stumps of vigorous stock up to the ages of 40 to 60 years, when cut in the fall or winter, may generally be counted on to send up healthy sprouts.

[1] Toumey, J. W.

Slow-growing trees beyond the ages of from 60 to 90 years will not ordinarily reproduce themselves successfully by sprouting. The corresponding diameter limitation is seemingly about from 10 to 14 inches at 2 feet above the ground. Girdled trees die and will not sprout when cut in logging. Along the Atlantic coast, on relatively dry sites, cypress sprouts successfully from both the top and the base of the stump (Pl. VI). Along the Gulf and Mississippi Valley only sprouts from the top of the stump, or wounded cambium, have been observed (Pl. V), although root collar sprouts may also occur.

YOUNG GROWTH.

Young cypress, although quite unevenly distributed, is present in larger amount than is popularly believed. Stands of young growth occur abundantly in openings in deep swamps generally throughout its range, but are notably absent from the better drained areas or ridges and all older upbuilding portions of swamps.

Along the Atlantic coast cypress appears to be more aggressive both in sprout and seed reproduction than over the Gulf States and Mississippi Valley. In the more northern portion of its range the germination per cent of the seed is lower and young growth is much less abundant than farther south.[1] In the Mississippi Basin where the soil is rich, strong competition by numerous hardwoods and other plants appears to reduce the amount of young cypress. It is worth special note that cypress reproduction is extremely prolific in the countless shallow ponds and bay heads over the Atlantic coastal plain from North Carolina to Florida. In the extensive occupation of former rice fields in South Carolina, surface water instead of wind has been the chief means of distributing the cypress seed. Because of the light, delicate foliage and deciduous leaf habit, cypress seedlings and saplings when present are apt to escape casual observation. Young cypress is characterized by its coming in gradually but growing persistently, often beneath the partial overhead shade of other species, until it reaches its normal position of dominance over all others in the forest stand.

A very wet swamp along the Santee River near Ferguson, S. C., contained a heavy stand of 2-year-old cypress seedlings from 14 to 20 inches[2] in height (shown in Pl. VIII). The maximum stand counted in this locality contained 219 seedlings in a square rod. This density, 35,000 per acre, was greater than that of any other species locally except overcup oak. The average stand on 500 to

[1] Kearney reported cypress in the Dismal Swamp as reproducing itself very slowly, so that an area once cut over for merchantable cypress was regarded by the lumberman as permanently exhausted. Seedlings were reported, however, as being plentiful upon narrow tracts of marshy land around the edge of Lake Drummond. (Report of a Botanical Survey of the Dismal Swamp Region, U. S. National Museum, Vol. V, No. 6, Division of Botany, U. S. Department of Agriculture, by T. H. Kearney.)

[2] Age confirmed by section examined under the microscope, Forest Service, November, 1913.

1,000 acres was estimated at between 4,000 and 6,000 per acre, although irregular in distribution and absent from many small areas. In general, it is more scattered and is confined to the wetter situations. In the green swamp of North Carolina young cypress was seen competing well with red maple, water oak, ash, and tupelo gum in tracts logged from 3 to 6 years ago. In four years cypress here grows to be from 4 to 6 feet high (Pl. VI). In the great delta region of southern Louisiana former cuttings were seen in which cypress reproduction was just as successful as willow and tupelo gum in taking the ground where seed trees had been left (Pl. V). Mohr,[1] who made extensive examinations of the region, says:

> In the dense forests which, for example, cover the shallow lakelike expansion of the lower Atchafalaya River and the flooded banks of the numerous channels of the mouth of the Red River, where the cypress occurs almost pure, reproduction takes place after the larger trees are removed.

In swamps a very decided change in the vegetation usually follows lumbering. This is due to the free exposure to light of surfaces previously under the dense shade of a high cypress forest, and the presence of many of the herbaceous plants and trees at the time of logging. Thus, cypress appears similar to white pine, northern spruce, and other species in returning slowly and fighting its way back, following heavy cutting in former virgin stands. Furthermore, in the case of cypress, if its former home has been upbuilding and becoming drier, the chances are against successful reproduction and the return of the species even in reduced numbers.

The cause for incomplete and unsatisfactory stands of young cypress are mainly:

(1) Inadequate supply of seed trees, due to close lumbering and the smashing of practically every remaining cypress of seed-bearing age by modern methods of steam logging.

(2) Inherent requirements of the seed and young seedling for moisture in great abundance for germination and early seedling development, which place the species at a disadvantage when in competition with others on upbuilding swamp areas.

(3) Heavy seed, which, unlike the seed of most conifers, is not freely scattered by wind.

(4) Death and injury of young seedlings, due to submergence and sometimes to stream deposition during periods of flood waters.

There is no record of close observations on the endurance of cypress seedlings under partial or complete submergence. The infrequent coincidence of heavy seed crops and favorable water levels during at least the first season following germination undoubtedly is an important factor in the amount of cypress reproduction. Delayed or long continued flood periods may result in very late germination of the

[1] Mohr, Charles, Forest Service manuscript, 1898.

FIG. 1.—ELEVEN-YEAR-OLD SEEDLING CYPRESS (X) AND STUMP SPROUT (XX) OF SAME AGE IN CUT-OVER AREA. WILLOW AND TUPELO GUM IN MIXTURE. (GRAND RIVER.)

FIG. 2.—VIGOROUS CYPRESS COPPICE, 12 YEARS OLD, 6 TO 10 INCHES IN DIAMETER.

NATURAL REFORESTATION FOLLOWING LOGGING IN LOUISIANA.

Fig. 1.—Cypress Seedlings (X) Successfully Competing with Hardwoods in Reforesting an Opening Logged 5 Years Ago.

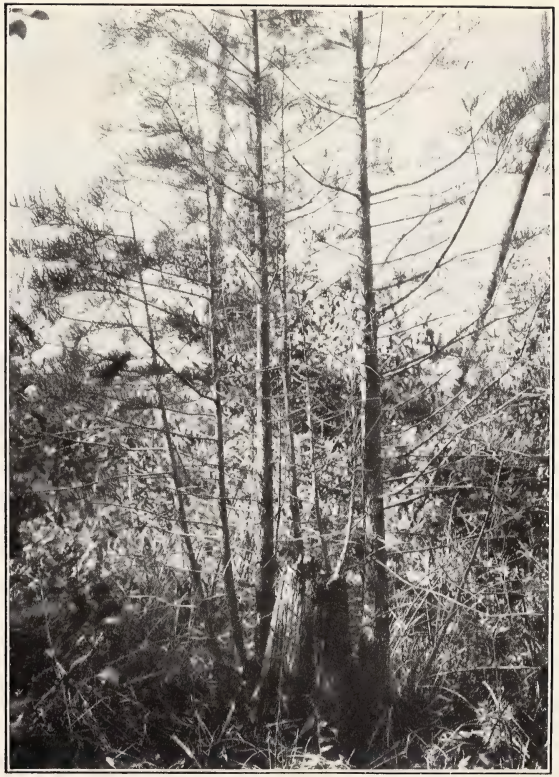


Fig. 2.—Sprout Reproduction from Tree 170 Years Old. Note Vigor of Sprouts from Base of Stump.

NATURAL REPRODUCTION IN THE GREEN SWAMP, NORTH CAROLINA.

FIG. 1.—CYPRESS ADVANCING INTO FORMER MARSH OR "PRAIRIE" AS THE PROCESS OF UPBUILDING PROGRESSES.

FIG. 2.—POLE CYPRESS, 140 YEARS OLD, NEARLY FILLING A SMALL "PRAIRIE" AND SURROUNDED BY CYPRESS 265 YEARS OLD IN FOREGROUND.

RELATION OF CYPRESS TO LIFE OF SWAMPS—OKEFINOKEE SWAMP.

FIG. 1.—DENSE STAND OF 2-YEAR-OLD CYPRESS REPRODUCTION IN OPENING.

Maximum stand of 219 seedlings per square rod, 15 to 20 inches in height. Water ash and tupelo gum associates in flat wet swamp. (Santee River, S. C.)

FIG. 2.—CYPRESS SAPLING AND POLE REPRODUCTION FOLLOWING LOGGING.

Logging 18 years ago made opening, now filled with young cypress from 7 to 16 years old. (Southern Louisiana.)

seed, which increases the susceptibility of the immature seedling to winter freezing.

Stands of mature cypress, but rarely any of young growth, occur on the ridges in the undulating swamp bordering such alluvial rivers as the Santee, Apalachicola, and Mississippi (fig. 2). The recent upbuilding of many of these ridges by the deposition of silt and other material during floods is clearly apparent; likewise the later excavations of some of them by swift flood currents, exposing the embedded bases of mature standing cypress trees. With the natural limitation of reproduction to the very wet sites, second-growth cypress is irregularly distributed in swamps, being found mostly in openings and especially on newly formed low, wet mud bars and banks (Pl. VIII).

Reproduction is notably more abundant in localities where cutting has been conservative than where logging has made a clean sweep.

The early float method of logging destroyed very little growing stock, the pull-boat method considerable, and under present methods of clean cutting the overhead-cableway skidder effects almost complete destruction of any part of the forest which happens not to be taken.

Evolution of the Okefinokee Swamp.—The relation of cypress reproduction to the progressive changes in the history of large inland swamps is interesting. This relation is intimate, and the comparative ages of various portions of the swamp—for example, the Okefinokee Swamp in Georgia—can be told approximately by the age and distribution of cypress in the forest stand.

Remnants of the original lake may be seen in the Okefinokee Swamp in the scattered bodies of open water. These are bordered by "prairies," or treeless marshes of considerable width (Pl. VII). In passing outward from the central open water toward the higher or older portions, one successively finds (*a*) widely scattered clumps of young, slow-growing cypress which obtained a foothold on the vegetable mounds or tufts, (*b*) dense stands of slender pole cypress, (*c*) mature stands of large-size trees where the swamp floor of humus and mulch has become quite stable, (*d*) overmature cypress trees scattered in a stand of black gum and white and red bays, and (*e*) on the outer and oldest portion, a high forest of pure hardwood with hardly a remnant of the former cypress stand. These successive stages are well shown in figure 3 on page 22. At the extreme edge of the swamp this type changes abruptly to a pure forest of either longleaf or slash pine over the broad, sandy pine flatwoods. The marshes range in size from a few rods in diameter ("alligator holes") to several hundred acres. One small "prairie" contained a few 10-year-old saplings surrounded by a large pole stand 140 years old, which in turn was inclosed by a marginal, even-aged stand of thrifty

cypress about 265 years old (Pl. VII). Outside of these successive age classes in the form of concentric rings, the main stand was mostly 300 to 400 years with a considerable mixture of bays and gum. In logging, only a few of the larger trees in the 140-year-old class and practically all of the surrounding older stand were taken.

The subsidence theory.—The theory that the Atlantic and Gulf coasts are gradually sinking is held by some to account for the irregular and unsatisfactory reproduction of cypress. This theory of a general subsidence is one upon which authorities hold quite opposite views. Those who believe in subsidence indicate a rate of about one-tenth of a foot in a decade. Cypress seed, however, usually germinates the first year, and the seedling makes an average growth of from 10 to 18 feet in height during the first decade. The prevailingly better reproduction of cypress on low wet situations than on better drained or upbuilding soils, except near salt water, is an evidence against the adverse effect of any subsidence that may be in progress by either checking the incoming of reproduction or subsequently retarding its growth. The effects, if any, from subsidence at so slow a rate would be more apt to appear in the tree during periods measured in centuries than during the few years of the reproduction stage. On upbuilding lands cypress is clearly receding before the hardwoods, and similarly, the best reproduction of cypress is found in very wet situations, where it is equally the dominating and the advancing species over all associated swamp hardwoods.

DEMANDS UPON CLIMATE AND SOIL.

CLIMATE.

Cypress grows in a wide range of temperature. Its natural range extends from below the frost line in southern Florida northward to New Jersey. Its extended potential range takes it northward to a line connecting Massachusetts and Michigan, where it experiences minimum temperatures of about −20° F. More than 90 per cent of the total cypress stand is found at an elevation of less than 100 feet above sea level. In the Middle Atlantic coastal States the 100-foot contour marks the upper line of elevation, while over the central Mississippi Basin the species prevailingly stops at an elevation of about 500 feet. Hundreds of miles west of the great coastal swamps cypress reaches large size around the edges of deep hollows on the Edwards Plateau of Texas at elevations ranging from 1,000 to 1,750 feet. It appears that atmospheric moisture and rainfall both play an unimportant part in the distribution of cypress, as compared with soil moisture.

SOIL.

Cypress thrives in a wide variety of soils, including muck, clays, and the finer sands. It has been commonly reported that sandy

soils are very unfavorable, but this is only in part true. Unable to thrive in impoverished or sterile sandy soils, cypress stands in a class with the ordinary hardwoods as distinguished from most of the other conifers, notably the pines. Of these, longleaf pine endures the deepest, driest soils of the South and thus presents the most striking contrast to cypress, since the two occur extensively on adjacent but extremely different sites. Sandy soils dry out quickly near the surface, thus preventing cypress from getting a foothold in the seedling stages. The beds of the larger Atlantic and Gulf coastal rivers are composed of varying soils of sandy and silty character. It is here that cypress finds the optimum conditions for its development. Except in the extreme northern portions of the State where the Lafayette clays are present, cypress in Florida occurs largely in sandy soils, but only where soil moisture is abundant and relatively permanent. Similarly, in the typical humus soils, such as occur in the Everglades, the presence or absence of cypress seems to depend upon the depth of surface drying during periods of drought and the presence at least of a minimum mineral component in the soil. In the shallow ponds scattered over the lower Atlantic and Gulf Coastal Plains, where natural conditions for advanced tree growth are decidedly unfavorable, both soil and moisture conditions appear singularly favorable for cypress-seed germination, and natural reproduction here is uniformly the most abundant in the whole geographical range. The poorly nourished, inferior form of "pond" cypress is found on this class of shallow, poorly drained soils.

On the whole, it may be stated that cypress finds its most congenial situation for adult growth in a deep, fine, sandy loam supplied with an abundance of soil moisture and well drained—the requirements for practically all trees. Cypress is usually found, however, in poorly-drained localities. Where cypress does occur on ridges or bars it is practically certain that the latter have been built up by natural changes and stream deposition since the incoming and early stages of the stand. The character of the growth of cypress planted on upland soil in the Ohio Valley and the North Atlantic States (see p. 64) furnishes corroborative evidence of the general correctness of the above conclusions, which were reached through a careful comparative study of the various qualities of situations where cypress occurs, and of the respective ages and rates of growth of the stands.

LIGHT REQUIREMENTS.

The quantity of light required by a tree for active growth is indicated by its tolerance. Since the various tree species vary widely in their respective demands for light, the tolerance of a species has much to do with its manner of occurrence in the forest stand. Cypress is able to endure partial shading for periods of considerable length,

but requires a good degree of overhead light for normal growth. Under moderate shading it makes a persistent but less rapid growth than in the open. Since there is no fixed scale for grading trees in respect to their tolerance, general classes only are used. Cypress is undoubtedly to be classed as moderate, or about midway, in the scale of tolerance. It appears to thrive with less light than tupelo gum, cottonwood, honey locust, red gum, ash, and willow, but requires more light than red maple, oaks, elm, hackberry, black gum, slash pine, and white cedar. Overhead light is required, but side shading accelerates height growth and natural pruning of limbs. In full stands cypress characteristically has a clean, smooth stem and small crown. In other words, it cleans itself readily of branches. The narrow-leaf form, or "pond" cypress, is less tolerant of shade than the broader, two-ranked or regular form of cypress.

SUSCEPTIBILITY TO INJURY.

In comparison with the important southern pines and hardwoods cypress ranks high in resistance to injury. The thin bark offers slight protection against fires, but these rarely occur in cypress stands except along the narrow margins of the deep swamps and over the shallow ponds. At intervals of many years dry periods occur, during which fire does considerable injury in the larger swamps. The general fire risk, however, in timber and logging is practically negligible. Insect attack on living trees may likewise be counted as of little consequence, and up to the age of 200 years, or about the average life of its common associates, cypress suffers only small injury from fungous disease.

CAUSE OF PECKY CYPRESS.

The fungus causing the well-known "pecky," "peggy," or "botty" cypress is present everywhere and in varying degree, but more particularly in virgin cypress stands during the overmature stage. It is found in all ages down to saplings, and occasionally infests stands from 75 to 150 years old. This fungus attacks only the heartwood of living trees, and destroys the wood in spots. The rate of growth and progress of infestation is very slow. The isolated disease centers gradually increase in size and force, resulting eventually in the destruction of all intervening wood and the formation of hollow limbs and trunk.

The life history of this fungus eluded careful investigation and was for many years only partially known. Von Schrenk made detailed investigations of the nature of pecky cypress,[1] and pointed out the striking similarity of the disease to the peculiar honeycomb rot in incense cedar (*Libocedrus decurrens* Torr.), a species of the Pacific

[1] Von Schrenk, Hermann, Missouri Botanical Gardens, 11th Annual Report, 1900, pp. 23–77.

coast which, like cypress, represents the flora of a previous geologic epoch. He did not, however, determine the cause of the disease. The junipers also are affected in a somewhat similar manner. Among other things, Von Schrenk pointed out that pecky cypress is most prevalent in the southern range, and decreases in amount toward the north in the colder climate. Investigations by the Bureau of Plant Industry, United States Department of Agriculture, in 1913, led to the discovery by Long[1] of the "punks" or fruiting bodies of this fungus on cypress and its identification as *Fomes geotropus* Cooke, a tropical and subtropical species infesting many of our southern hardwoods, and closely related to *Fomes ulmarius* Fries. of Europe. In the base, the presence of water in abundance causes vigorous activity, and the entire heartwood is frequently destroyed, leaving hollow butts. The fungus is most prevalent, however, in the upper portions of trees, where it gains entrance, presumably, through wounds in the bark. On account of lack of sufficient moisture, its growth here is very slow. In the case of broken-off tops, cavities are formed in which rain water collects, thus affording conditions of moisture and free air circulation favorable to the leaching and disintegration of the resin in the wood and the resultant advance of the fungus. Loggers sometimes discover large, apparently sound cypress trunks consisting of only a shell of sapwood above the base. The pecky fungus is perhaps indirectly the most active cause of the death of cypress, since it eats out the supporting heartwood, allowing the wind to tear down piece by piece the remaining portions of the tree. As indicated on page 16, pecky cypress is one of the standard grades of lumber. Because it is strong in proportion to its weight and because, so far as is known, its lasting qualities are not affected, it is valuable, and is used extensively for many purposes.

The immunity of cypress wood to bluing gives it a marked economic advantage both in logging and milling. At present great numbers of logs that have lain for 15 to 25 years in the swamp are being utilized. The lumber from such logs averages somewhat darker in color, but in general can not be distinguished from stock freshly felled.

INSECT DAMAGE.

Extensive investigations conducted by the Bureau of Entomology, United States Department of Agriculture, show that the principal insect damage to bald cypress is that caused by several species of pinhole borers or ambrosia beetles in the wood of girdled trees, logs cut from living trees, and freshly sawed lumber.

For full information regarding this kind of injury and the methods recommended for preventing losses, the reader is referred to Circular

[1] Long, W. H. A preliminary note on the cause of "pecky" cypress. Phytopathology 4, No. 1: 39, F., 1914.

82 of the Bureau of Entomology, United States Department of Agriculture, entitled "Pinhole Injury to Girdled Cypress in the South Atlantic and Gulf States;" also Circular 128 of the same bureau,[1] entitled, "Insect Injuries to Forest Products."

WIND.

Wind causes shake in the wood, and breaks down living trees when badly weakened by decay. The majority of trees, especially the veterans, reach their death through the combined agencies of the pecky fungus, causing hollow hearts, and wind pressure. Strong inshore gales combined with periodic high seas produce storm tides which invade and submerge large areas not usually reached by salt water. Unable to withstand exposure of this sort, the cypress in low seacoast swamps is sometimes badly injured both by the saline matter in solution and the mechanical force of high waves. Probably this in great measure accounts for the large amount of defective cypress sometimes seen along the coast, particularly on low advancing river estuaries and deltas. The breaking of protecting barrier sand reefs, the opening of tidal inlets, and other local changes in shore lines sometimes cause a permanent invasion by the sea which injures or kills the standing forest.

EFFECT OF SUBMERGENCE.

The effect of permanent submergence upon the subsequent growth of cypress depends chiefly upon the rate at which it takes place and the amount of deposition which results. The tree is apparently not injured by deep submergence for periods of a few weeks only. Instances of rapid inundation by the sudden subsidence of land areas are rather frequent over the comparatively recent land formations where cypress finds its home. Shaler[2] cites a conspicuous instance in the Mississippi basin of western Tennessee in which extensive tracts of cypress land were flooded by subsidence accompanying the earthquake of 1811. Wherever the sinking brought the water permanently to a considerable depth above the former level the trees died. About 1870 he observed that Reelfoot and other lakes were covered by the stately columns of the trees thus killed during the lapse of over two-thirds of a century. Near the outer margins the trees survived. In artificial flooding, where the permanent water level is brought above the knees, the trees have been reported by some observers to be injured or killed.

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[1] The supply of Circular 82 is exhausted; Circular 128 is listed as available from the Superintendent of Documents, Washington, D. C., price, 5 cents. Both are on file in all larger public libraries.

[2] Memoirs of Museum of Comparative Zoology, Harvard College, Vol. XVI, pp. 1–11.

In Chipola Lakes (locally known as "Dead Lakes"), tributary to the Apalachicola River in Florida, a subsidence of from 3 to 6 feet has been followed by the gradual dying of a heavy, pure cypress stand over a nonalluvial area about 10 miles long by about half a mile in width. Many trees, however, still persist with a fragment of life after standing in clear water about 70 years. Repeated top fires, started by fishermen and others, during dry seasons, in the dense festoons of Spanish moss have left clear evidence of their part in the killing of the stand. On adjacent lands along the Apalachicola River, where alluvial deposits kept pace with the subsidence, the bases of mature cypress trees lie deeply buried, yet very old trees are still living. A splendid young stand of cypress and ash about 48 years old covers the deep, rich alluvial soil, indicating the close of the period of rapid subsidence. The effect of draining swamp lands is discussed on page 53, where it is shown that the effect of ordinary draining is slight.

GROWTH.

In considering the growth in diameter, height, and volume, it is essential to distinguish clearly between trees grown in the virgin forest and those grown in the open, or second growth. Because the rate of development is so widely different in the two cases, it is essential to have two sets of tables for comparison. Measurements indicate little difference in the rate of growth of cypress between the warmer and the cooler regions of its natural distribution. Trees planted in Pennsylvania and Ohio, north of its natural range, are growing about as rapidly as the natural growth in various parts of the South.[1]

Wounds in the bark are healed at the rapid rate of three-fourths to 1 inch per year on each side of the wound. One tree 330 years old overgrew a fire scar 6.8 inches across in 4 years. Most remarkable is the continuance of life in the stump sometimes for several years without the formation of vegetative sprouts. In this manner the tops of stumps from 18 to 24 inches across occasionally are found fully calloused over and living several years after cutting.

GROWTH IN HEIGHT.

Cypress seedlings grow at a very rapid rate. This aids the young tree in reaching above the ordinary levels of surface water. Few if any conifers besides cypress commonly reach heights of from 8 to 14 inches the first season and from 16 to 24 inches the second season. (See Table 6.)

[1] See "Cypress under Cultivation," p. 64.

TABLE 6.—*Height growth of cypress saplings under full light in southern Louisiana.*[1]

Age.	Height.	Age.	Height.	Age.	Height.
Years.	*Feet.*	*Years.*	*Feet.*	*Years.*	*Years.*
1	0.8	5	5.5	8	11.4
2	1.7	6	7.0	9	14.8
3	3.0	7	9.0	10	18.8
4	4.3				

[1] Based upon age counts of 110 trees from 3 to 32 years old. This and the following tables of growth and volume in Louisiana are based on measurements by F. T. McLean, Forest Examiner, Forest Srevice.

Second-growth or open-grown cypress in Louisiana averages 16 or 18 feet in height at 10 years, 31 feet at 20 years, and continues at a gradually diminishing rate until it reaches a full height of about 100 feet in the first 100 years. The height continues to increase during the next one to three centuries; then the fungus causing pecky cypress disintegrates the heartwood in the top and winds start the downward or backward stage in the height of the tree. The average heights of stands 350 to 500 years old are perhaps about the same as young virgin stands at 60 to 80 years; the prime stage in respect to height is approximately from 150 to 300 years. Individuals which live to be 600 years old probably spend about one-half of their time in the decadent stage.[1]

Table 7 shows the height at various ages up to 100 years of second-growth cypress in Maryland and Louisiana supplied with abundant overhead light, as, for example, in logged areas. While the height growth of virgin stands may be interesting, knowledge of the rate of growth of younger stands is more valuable in figuring the profitableness of managing young cypress forests. The three columns of growth in Table 7 represent three grades of favorableness of situation. In comparison, the slow height growth shown in Table 8 of trees grown under the heavy shade of virgin forests is very striking.

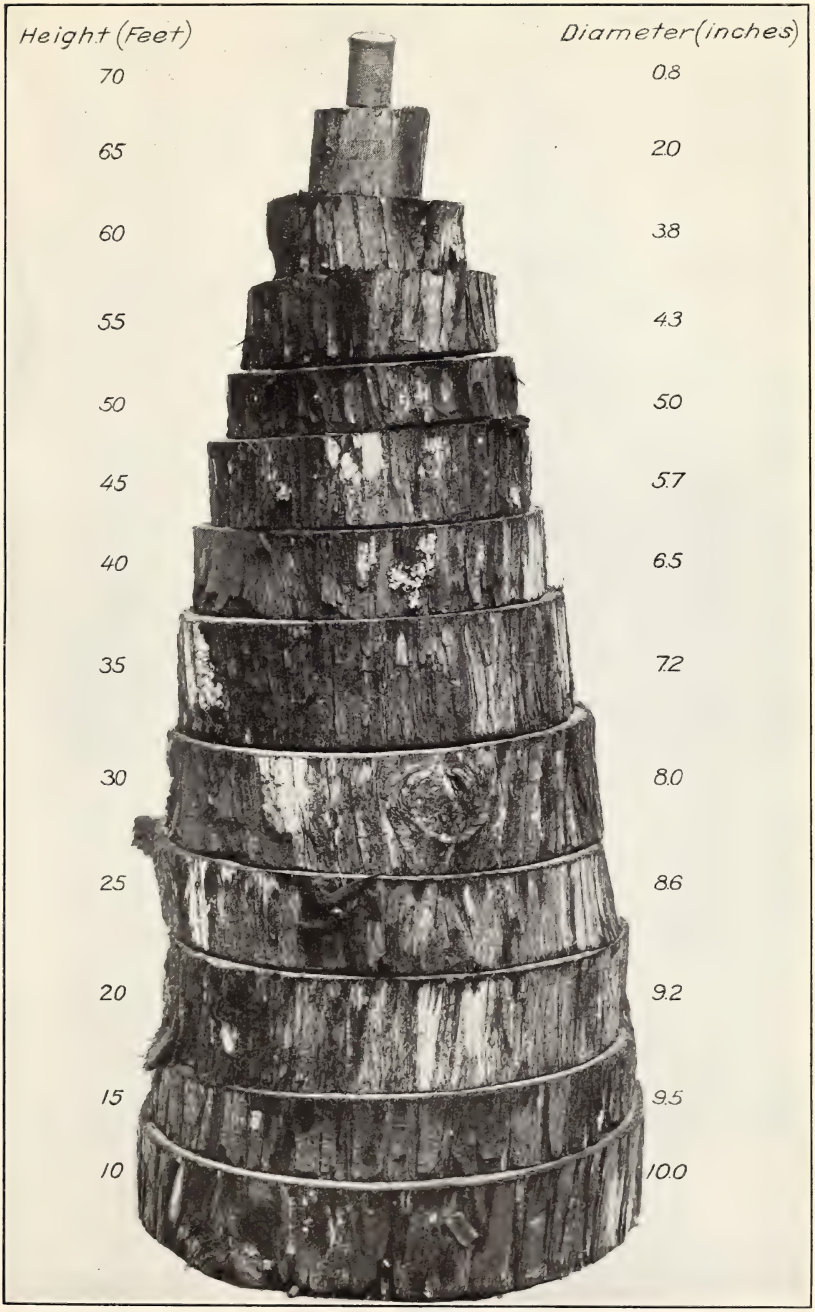
TABLE 7.—*Height of second-growth cypress on the basis of age.*

Age.	Height.					
	Maryland.[2]			Louisiana.[3]		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
Years.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
10	26	11	3	24	17	9
20	44	22	7	45	31	17
30	58	33	12	61	43	26
40	71	46	18	75	54	34
50	82	60	25	86	65	43
60	91	72	32	97	74	51
70	99	81	39	.....	83	60
80	106	88	44	.....	92	69
90	113	95	50	.....	101	78
100	119	101	54	.....	109	86

[1] Acknowledgment is made to Mr. George E. Watson, secretary of the Southern Cypress Manufacturers' Association, and various operating members of the association, for assistance rendered the writer in the collection of field data used in the bulletin.

[2] Based on sectional age counts of 68 trees, also total heights of 221 additional trees 6 to 103 years old.

[3] Based on sectional age counts of 42 trees 38 to 89 years old.



AVERAGE SECOND GROWTH CYPRESS ON CUT-OVER LANDS. (GRAND RIVER BASIN, LA.)

Height, 74 feet; diameter (breasthigh), 13 inches; age, 48 years. Compare with virgin forest growth, Plate X, figure 1.

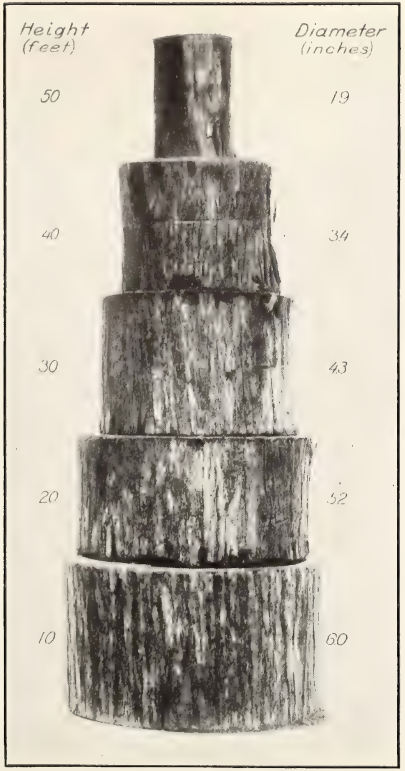


FIG. 1.—AVERAGE YOUNG POLE CYPRESS GROWN IN VIRGIN FOREST.

Height, 62 feet; diameter (breasthigh), 8 inches; age, 46 years. Compare with second-growth cypress in Plate IX.

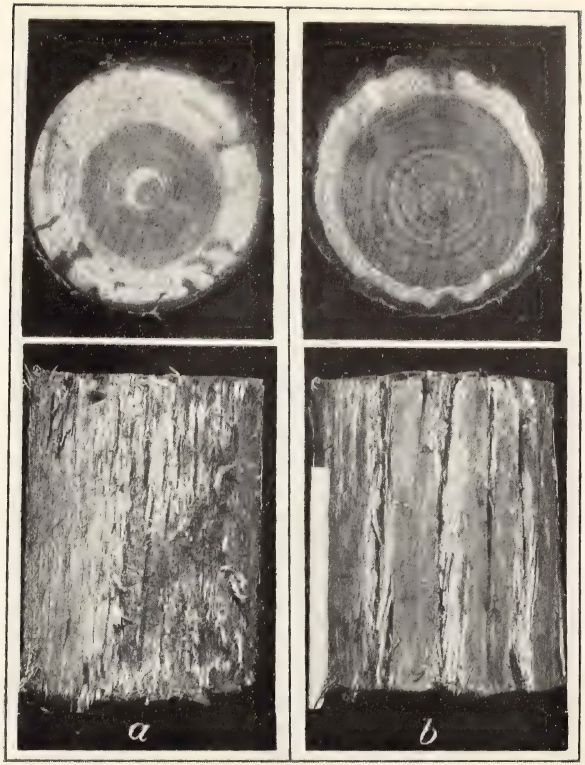


FIG. 2.—BOTANICAL FORMS OF CYPRESS. (ST. JOHNS RIVER, FLA.)

a. Thin, brown bark and wide sapwood.
b. Thick, reddish bark, narrow sapwood and darker heartwood.

TABLE 8.—*Height of cypress growing in virgin stands, on the basis of age.*

Age.	Height.					
	Louisiana.[1]			Maryland.[2]		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
Years.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
10	25	15	5	16	11	4
20	49	30	10	33	23	8
30	65	40	15	48	35	12
40	74	47	20	62	46	17
50	80	53	25	74	56	22
60	85	58	30	83	65	29
70	90	63	35	90	73	35
80	93	67	40	97	80	42
90	96	70	44	103	86	48
100	99	74	49	108	91	53
110	101	77	53	113	96	58
120	103	81	58	118	100	62
130	105	84	62	122	104	66
140	107	87	66	125	107	70
150	108	89	70	129	110	74
160	109	91	73	132	113	77
170	110	93	76	136	116	79
180	111	95	79	139	118	82
190	112	97	81	142	121	85
200	113	98	83	146	124	87
210	114	99	84	.....	.....	.....
220	115	100	85	.....	.....	.....
230	115	101	86	.....	.....	.....
240	116	102	87	.....	.....	.....
250	117	103	88	.....	.....	.....

[1] Based on sectional age counts of 73 trees, 88 to 793 years old.
[2] Based on sectional age counts on 22 trees, also total heights of 77 additional trees, 104 to 199 years old.

Cypress, like shortleaf and loblolly pines, culminates its rate of height growth usually in the second decade. Both of the pines, however, make a somewhat faster average annual growth than cypress. Second-growth cypress in Louisiana, exposed freely to overhead light, increase about 12 feet in the period between the ages of 20 and 30 years, while loblolly pine in North Carolina averages about 15 feet. In virgin stands the young trees grow up under more or less overhead shade due to the height and density of the cypress canopy, with the result of a decrease in growth. The growth by decades of cypress and loblolly pine is shown in Table 9.

TABLE 9.—*Height growth by decades for virgin and second-growth cypress in Louisiana* [1] *and virgin loblolly pine in North Carolina.*[2]

Species.	Decade beginning at age of—												
	20	30	40	50	60	70	80	90	100	110	120	130	140
	Height growth—feet.												
Virgin cypress	10	7	6	5	5	4	4	4	4	4	3	3	2
Second-growth cypress	12	11	11	9	9	9	9	8	(3)	(3)	(3)	(3)	(3)
Loblolly pine	15	13	10	9	7	6	5	4	3	3	2	2	2

[1] See Tables 6, 7, and 8.
[2] Ashe, W. W., Loblolly pine study in North Carolina. Based upon about 1,000 trees.
[3] Figures not available.

The slower initial but more sustained rate of growth in cypress as compared with the faster initial growth but earlier decline in rate in loblolly pine is clearly seen in Table 9. It is quite notable that between the ages of 90 and 100 years the two species are growing in height at about the same rate, and afterwards cypress leads until about 150 years. In the second century, loblolly pine averages 20 feet and cypress 24 feet of growth in height. The region of greatest height for cypress is apparently in South Carolina and Georgia, where also probably occurs the largest average diameter. Stands frequently average 125 feet in height, and individual trees 140 feet high are scattered through the forest.

GROWTH IN DIAMETER.

Cypress is popularly considered a tree of very slow growth. This belief is due to the slow rate of growth of virgin timber, and is justified by measurements shown in Table 12. In regard to second-growth or open-grown cypress the case is very different. The diameter growth of the latter, shown in Table 11, compares well with that of the more important southern hardwoods and some of the pines.

Annual increase in diameter is markedly irregular in individuals from year to year, or in successive periods of years. Cypress is extremely persistent in diameter growth. Old hollow trees grow steadily at about the same annual rate for several centuries.[1] In this character, cypress closely resembles the redwoods of the western United States, in contrast with the southern pines, which at a very much earlier age fall off in the rate of their diameter increment. Table 10 shows that there is little variation during the first 200 years in rate of growth at breastheight of virgin cypress in Louisiana. Second-growth in Maryland, between 60 and 100 years, is very uniform at a rate of 1 inch in every 5 years.

Measurements on trees up to 800 and 900 years old show the beginning of a marked decline in diameter growth at points varying from 350 to 500 years, and occasionally not until the tree reaches the age of 600 years.

[1] Annual rings of growth on the swell-butted stump of cypress are very faintly marked lines often difficult to distinguish. False rings consisting of well-marked brown bands or stains are numerous, especially in early life, and easily mistaken for true rings unless close attention is given.

TABLE 10.—*Diameter of a 900-year-old cypress at the end of successive 50-year periods (Louisiana).*[1]

Age.	Diameter.	Time required to grow 1 inch.	Age.	Diameter.	Time required to grow 1 inch.
Years.	*Inches.*	*Years.*	*Years.*	*Inches.*	*Years.*
50	6.0	8.3	500	65.8	8.6
100	12.5	7.7	550	72.5	7.5
150	18.5	8.3	600	79.0	7.7
200	25.9	6.8	650	84.2	9.6
250	32.4	7.7	700	87.8	13.9
300	39.4	7.1	750	91.2	14.7
350	46.1	7.5	800	94.1	17.2
400	54.0	6.3	850	98.6	11.1
450	60.0	8.3	900	103.2	10.9

[1] Measurements at breastheight on the stump, inside bark, taken along an average radius, doubled to obtain diameters. Lake Maurepas region, Livingston Parish, La. Total age of tree, 915 years.

TABLE 11.—*Diameter increase of second-growth cypress in Maryland, based on age.*[1]

Age.	Diameter breast high.			Diameter outside bark at 20 feet above ground.		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
Years.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
10	5.1	1.1	0.4	3.5	----------	----------
20	10.0	3.5	1.2	7.8	2.1	0.2
30	14.2	6.2	2.2	11.2	4.5	1.0
40	17.6	8.7	3.3	13.8	6.7	1.9
50	20.5	11.1	4.4	15.6	8.7	3.0
60	23.2	13.3	5.8	16.9	10.4	4.1
70	25.8	15.3	7.2	17.9	12.1	5.4
80	28.6	17.3	8.9	18.9	13.6	6.9
90	30.8	19.3	11.0	19.8	15.0	8.6
100	33.3	21.3	13.2	20.6	16.1	10.3

[1] Based on decade measurements on 237 stumps of trees 7 to 101 years old.

Because of the enlarged base of cypress in very wet soils the breast-high diameter (4.5 feet above the ground) is not a good index to the volume of the tree trunk, except after middle life. At the height of about 20 feet (about the top of the first 16-foot log) the character of diameter growth is comparable with that at breast-height of common upland trees and serves well as an index to the contents of the whole tree.[1] Table 11 indicates that a butt log 8 inches at the top end[2] can be grown in about 46 years, a 12-inch log in 70 years, and a 16-inch log in 100 years.

The trees of the virgin forest started, as a rule, under a moderate or light overhead shade, and their growth was therefore slower than than that of young trees either in natural stands in logged forest areas or in stands thinned under intensive forest management.

[1] Diameter inside bark, allowing ½ inch for width of bark.

[2] The large basal swell and close utilization in milling give overruns estimated at 25 to 40 per cent, and more in young and deeply submerged timber.

TABLE 12.—*Diameter of virgin cypress in Louisiana, based on age.*[1]

Age.	Diameter breast high.	Diameter outside bark 20 feet from ground.	Age.	Diameter breast high.	Diameter outside bark 20 feet from ground.
Years.	*Inches.*	*Inches.*	*Years.*	*Inches.*	*Inches.*
10	0.8	.....	110	12.8	7.3
20	2.3	.....	120	13.7	8.0
30	3.7	0.6	130	14.6	8.7
40	5.0	1.5	140	15.5	9.4
50	6.2	2.4	150	16.3	10.0
60	7.5	3.2	160	17.1	10.6
70	8.6	4.1	170	17.8	11.2
80	9.7	4.9	180	18.6	11.8
90	10.8	5.7	190	19.3	12.3
100	11.8	6.5	200	20.0	12.8

[1] Based on decade measurements on 68 stumps, 92 to 791 years old (average, 263 years).

There is good evidence based upon the measurement of a large number of trees that diameter growth of cypress under similar local situations over its northern range, for example Missouri and Maryland, is practically the same as throughout the Southern States. In strongly acid and shallow soil, where growth is exceedingly slow, trees from 8 to 10 inches at breastheight may be from 180 to 240 years old.

GROWTH IN VOLUME.

The combined growth in height and diameter determines the growth of a tree in volume. Commercially it is very desirable that the volume increment be made by trees as cylindrical in form and free of branches as possible.

Large cypress trees, measuring from 5 to 8 feet in diameter, often contain from 5,000 to 10,000 board feet of merchantable lumber. A 4-log tree in the Okefinokee Swamp scaled 6,875 board feet,[1] a 5-log tree scaled 12,025 feet, and 3 logs from one tree cut 9,900 feet mill scale. A 5-log tree on the St. Johns River in Florida cut out 9,600 feet. There is record on the Santee River, South Carolina, of one 22-foot log scaling 4,000 board feet. In stands running from 12 to 16 inches in diameter, as many as 10 to 15 logs are required for a thousand board feet. The log run probably averages now mostly between 3 and 5 logs per thousand,[2] although the size of the cypress logged in the same region varies greatly. In 12 consecutive days in 1913 one large company in southern Louisiana, which is clean-cutting a typical deep cypress swamp, hauled out 2,742,000 feet, averaging a little less than 5 logs per thousand feet, or about 208 feet per log.

Tables 16 and 17, given in discussing the value of the timber crop, show the relation between increase in diameter and volume. Volume

[1] Doyle scale.

[2] In 1897 in a typical logging operation, Roth found an average of 10,000 logs to run about 300 feet, or $3\frac{1}{3}$ logs to the thousand board feet.

tables showing cubic volume based upon the diameter of the tree measured outside the bark at the middle point of the trunk ("Schiffel's" method) are being increasingly used. Strangely, this middle-point method when applied to cypress gives very accurate results compared with the actual log volume.[1] Forty trees from 11 to 56 inches in diameter showed an error of only 0.2 per cent.

TAPER.

The taper of cypress above the basal swell is considerable in very young and in isolated trees, moderate later in life, and, in forest stands, very slight at maturity. The amount and variation in the basal swell have been discussed on page 24. One tree on the Santee River, South Carolina, tapered 5 inches, or from 54 to 49 inches, in a cut of four 16-foot logs. A taper of 2 inches to each 16-foot log prevails with singular uniformity in middle life, and may be accepted as an approximate rule. Table 22 in the Appendix shows the diameters at various heights above the ground up to 5 feet. The actual taper of cypress is usually greatly overestimated because of the striking comparison with the enlarged base. Judging from all measurements, the stem of cypress above the basal swell does not differ greatly in its taper from that of the southern pines.

EFFECT OF DRAINAGE UPON CYPRESS GROWTH.

Although essentially a silvical question, the effect of draining upon the growth of cypress is of interest in a general discussion of swamp-land reclamation. While there is insufficient direct evidence and no experimental data in regard to the effect of heavy draining upon the growth of cypress, certain conclusions may be stated tentatively.

A sudden and decided lowering in the permanent water level is very likely to produce injurious results to tree growth by the disturbance in the former equilibrium between the root system and water supply. Cypress is believed to possess to a large degree the power of adjusting its root system to meet its requirements for growth under a gradual reduction in the soil water. A mature cypress stand at Walls, Miss., was in a healthy condition when cut in 1913, 15 years after the deep but gradual draining of the slough in which it grew.[2] Mr. H. B. Hewes,[3] Jeanerette, La., however, states that cypress on lands in Avoyelles Parish, La., previously reclaimed by levees along the Atchafalaya River, when examined showed considerable decay at the bases of the trees. A moderate amount of drainage will undoubtedly be as beneficial to cypress as

[1] Tables 18 to 21 in the Appendix show the volumes of cypress in Maryland, South Carolina, and Louisiana.

[2] Wallis, W. R., Civil Engineer, Walls, Miss.

[3] Chairman of a special committee of the Southern Cypress Manufacturers' Association, New Orleans, La., for studying the utilization of cut-over lands.

to various other species when growing in an excess of water. Temporary effects must always be distinguished from permanent injury or benefit, and further detailed observations before and at successive periods following the drainage will be necessary in the case of cypress before the effects can be completely stated.

CYPRESS STANDS.

Cypress occurs both in pure stands and in mixture with various hardwoods. It may be said to be a tree of even-aged groups within all-aged stands. This is due to the very intimate relation between water level and successful seed germination mentioned in the discussion of reproduction and the transitory character of swamps as compared with dry-land farms. In considering trees in the aggregate, or stands, it is essential to know (1) the composition of the stand, and (2) the amount of timber produced per acre under different conditions, or the yield.

PURE STANDS.

Cypress forms practically pure stands in the back swamps, oxbows, or cut-offs, and the deep swampy portions of alluvial river flood plains. These places are commonly known as "sloughs" and the bodies of pure cypress as "cypress brakes." In the large inland swamps of the Atlantic Coastal Plain pure stands of cypress occur in the form of concentric rings of progressive-age classes around the bodies of open water. The home of the pure or nearly pure cypress forests of large extent is in Louisiana and Florida, in deep swamps overflowed for a portion of the year. Pure stands of cypress, although widely distributed, are local rather than regional in their occurrence. Cypress is characteristically the dominant tree wherever it occurs. The number of trees per acre and the amount of timber in pure stands is discussed on page 48, under the subject of "Yields."

MIXED STANDS.

The home of the mixed cypress and hardwood forest is on the undulating portions of swamps, known as glades. These occupy an intermediate position between the ridge on one side and the slough or back swamp on the other (see figs. 2 and 3, p. 22). In wet or swampy situations in the Southern States slight differences in the lay of the land, with accompanying differences in moisture content, cause a wide diversity in the character of the forest stand. The glade formation is the prevailing type over much of the southern swamp lands. During periods of high water the glades are overflowed for several weeks at a time, but become partially drained after the floods disappear. The average water table is usually from 1 to 2 feet below the surface. Over the glades cypress is supreme in all the depressions and water holes, and occurs both in groups and in pure stands.

TABLE 13.—*Composition of typical mixed cypress and hardwood stands in Maryland and South Carolina.*

Species.	Trees per acre and relative importance in the stand.			
	Maryland (average of 103 acres).		South Carolina (average of 599 acres).	
	Trees.	Per cent.	Trees.	Per cent.
Cypress	38.92	23.53	58.14	45.19
Black gum	35.46	21.44	23.99	18.65
Red maple	31.67	19.15	5.59	4.34
Red gum	22.01	13.31	3.33	2.59
Ash	13.89	8.40	.90	.70
Elm	7.76	4.69	.23	.18
Cottonwood	6.18	3.73	.....	.....
Black oak	1.83	1.11	2.29	1.78
White oak	2.22	1.34	.40	.31
Yellow poplar	.01	.01	1.08	.84
Hickory	.01	.01	.18	.14
Beech	1.06	.64	.14	.11
Holly	1.71	1.03	.05	.04
Sweet magnolia	.56	.34	.04	.03
Willow	.52	.31	.....	.....
Persimmon	.13	.08	.....	.....
River birch	.58	.35	.....	.....
Longleaf pine	.....	.....	.55	.43
Loblolly pine	.88	.53	31.45	24.45
Red cedar	.....	.....	.28	.22
Total	165.40	100.00	128.64	100.00

Cypress is a tree of relatively few associates. These are all hardwoods, with the exception of southern white cedar. Preeminent among all associated species in the deeper and fresher waters from Virginia to Texas is tupelo gum.[1]

In the inland, poorly drained, nonalluvial and peaty swamps over the Atlantic Coastal Plain black gum holds nearly the same rank. Other species associated with cypress are water ash, water locust, white or swamp bay, and red bay on the Atlantic coast; these and the cabbage palmetto, willow oak, and water oak in Florida, and in Louisiana the willows and tupelo gum.

On the higher and drier portions of the glades in southern Louisiana, where cypress is not reproductive, the heavy forest is com-

[1] Common and botanical names of species mentioned in this and other paragraphs of this bulletin:

Tupelo gum (*Nyssa aquatica* Linn.).
Black gum (*Nyssa sylvatica* Marsh).
Water gum (*Nyssa biflora* Malt.).
Red gum (*Liquidambar styraciflua* Linn.).
Water oak (*Quercus nigra* Linn.).
Overcup oak (*Quercus lyrata* Walt.).
Willow oak (*Quercus phellos* Linn.).
Red oak (*Quercus rubra* Linn.).
Swamp white oak (*Quercus platanoides* Sudw.).
White bay (*Magnolia glauca* Linn.).
Red bay (*Gordonia lasiantha* Ell.).
Cabbage palmetto (*Sabal palmetto* Roem.).
Red maple (*Acer rubrum* Linn.).
Cottonwood (*Populus deltoides* Marsh).
Water ash (*Fraxinus caroliniana* Mill.).
Florida ash (*Fraxinus floridana* Sarg.).
Green ash (*Fraxinus lanceolata* Borkh.).
White ash (*Fraxinus americana* Linn.).
Hackberry (*Celtis occidentalis* Linn.).
Honey locust (*Gleditsia triacanthus* Linn.).
Water locust (*Gleditsia aquatica* Marsh).
White elm (*Ulmus americana* Linn.).
Shipping elm (*Ulmus fulva* Michx.).
White cedar (*Chamaecyparis thyoides* Britt.).
Slash pine (*Pinus caribæa* Morelet).
Spruce pine (*Pinus glabra* Walt.).
Pond pine (*Pinus serotina* Michx.).
Longleaf pine (*Pinus palustris* Mill.).
Loblolly pine (*Pinus taeda* Linn.).
Shortleaf pine (*Pinus echinata* Mill.).

posed chiefly of red maple, water oak, red oak, ash, honey locust, hackberry, and red gum, in association with mature cypress. In southeastern Mississippi a tract of 807 acres, mostly overflowed in winter and spring, contains the following hardwood associates of cypress, stated in the order of their relative importance: Ash, white and red elm, red maple, red and tupelo gums, various oaks, hackberry, hickory, and cottonwood. In all of these higher glades groups of pure cypress occur in the depressions, and elsewhere older trees are scattered in mixture with the hardwoods. The gradual shifting of the main currents during floods produces changes in the location and height of the ridges in the glades, together with corresponding changes in the composition of the forest due to the different moisture requirements of the various species.

Over the southern Atlantic Coastal Plain, mature red gum, overcup oak, water elm, water and Florida ash, and bitternut hickory occupy the low ridges in the large river swamps. Tupelo gum, water ash, and small amounts of cottonwood and water locust, along with cypress, stand in water during much of the year. Two other types in this region are found in the nonalluvial Dismal and Okefinokee Swamps, and the mixed white cedar and cypress swamps from Virginia to Florida. The Okefinokee forest is made up essentially of heavy stands of pure cypress over the younger and middle-aged portions, and a dense hardwood forest with scattering veteran cypress over the older-aged portions of the swamp (fig. 3). Among the hardwoods, black gum leads, and there is much white bay, red bay, red maple, and willow and water oak. The more valuable yellow poplar, red gum, and ash, if present, are in very small quantities. The white cedar peat swamps contain varying mixtures of cypress and white cedar, with pond and slash pine around the borders.

Along the swamp borders cypress closely meets the many conifers and hardwoods which compose the upland forests of the Southeast. The small cypress ponds of the flat, pine-barren type contain small amounts of water gum, a dwarf form of the black gum, while pond, spruce, and slash pines are encroaching actively from the outside as the ponds become drier through the destruction of the surrounding pine forest.

YIELD.

In pure stands and in the better cypress regions of the Southern States, particularly Louisiana and Florida, virgin cypress yields of 8,000 to 14,000 board feet per acre are not uncommon over tracts several hundred miles in extent. The size of the trees and density, or number of trees per acre, is very irregular. In a few localities manufacturers are now cutting bodies of pure cypress containing a total of up to 100,000,000 feet, which will average more than 20,000 feet per acre.

In many important timber species a commonly accepted standard of the "cut" of average stands becomes well established. Thus, in the better cypress regions, a cut of 12,000 to 15,000 feet per acre is a recognized standard over large areas. One fully stocked cypress stand of mixed ages along the Apalachicola River in Florida, ranging from large mature trees 40 inches in diameter down to 10-inch trees, contained an average of 112 cypresses and 48 hardwoods (chiefly tupelo gum), or a total of 160 trees per acre. The indicated yield, by Doyle rule (Appendix, Table 20), after allowing 20 per cent for defect, was 43,600 feet of cypress per acre. In Louisiana, an average yield of 45,000 feet per acre is limited to relatively small areas of timber. Maximum yields of virgin cypress of from 50,000 to 60,000 per acre occur on small tracts or cypress "brakes" in the most favorable situations. Stands are reported as having cut 100,000 feet on selected acres. One acre on Grand River, Louisiana, was estimated by an experienced lumberman to contain 127,000 feet of merchantable cypress.[1]

The best cut in several years in a representative region in the Grand River basin in southern Louisiana was an average of 35,000 feet per acre from a 40-acre tract, or a total of 1,400,000 board feet. During a period of 50 years or more early float logging culled out many individual cypress trees, mostly in localities subject to periodic high water and near main water courses. The average yield per acre, also the average grade, increases notably in many logging operations upon working away from the water fronts farther back into the deep swamps.

A 30-year old stand of cypress in an old cutting in Louisiana, where sufficient seed trees had been left, contained an average of 340 trees per acre about 5 inches in diameter at breastheight. Mature cypress stands, from 250 to 350 years old and well stocked, usually contain from 40 to 60 trees per acre. In more scattered and typical stands, in some regions, the trees from 12 to 20 inches in diameter may average about 40 trees per acre, older timber from 18 to 24 inches in diameter about 30 trees per acre, and stands of large trees from 2 to 4 feet in diameter mostly from 15 to 20 trees per acre over large areas.

The number of trees per acre and the size of the individual trees both show great irregularity in tracts as small as 40 acres. Cypress occurs mostly in all-aged stands made up of several even-aged classes. As virgin timber becomes more scarce and second-growth cypress more valuable and important there will be need for yield tables of fully stocked pure stands for use in calculating future yields and returns from management.

[1] Capt. E. T. Forgey, Morgan, La.

FOREST MANAGEMENT.

The possibilities of cypress as a tree of large commercial importance under forest management in the future depends very largely on the extent to which denuded swamp lands can be utilized. Obviously, these lands if drained would be very valuable for agricultural use. Therefore a discussion of the probability of the lands being successfully adapted to agriculture is a prerequisite to the consideration of the advantages, aim, and methods of forest management.

FUTURE UTILIZATION OF CYPRESS LANDS.

AREA AND OWNERSHIP OF PERMANENT SWAMP LANDS.

Of the various classes of swamp lands requiring drainage to fit them for profitable cultivation, cypress occupies the extreme class known as "permanent" swamps. These lands are never fit for cultivation in their natural state, even during the most favorable seasons, and those portions that may be grazed afford forage of very uncertain value. So far as revenue is concerned, the lands may be considered as unproductive, except for the growth of timber. The total area of such permanent swamp land in 10 of the States where cypress occurs is approximately 42,440,000 acres, distributed as shown in Table 14:

TABLE 14.—*Permanent swamp area in 10 of the most important cypress producing States.*[1]

State.	Area.	State.	Area.
	Acres.		*Acres.*
Florida	18,000,000	Georgia	1,000,000
Louisiana	9,000,000	Missouri	1,000,000
Arkansas	5,200,000	Alabama	900,000
Mississippi	3,000,000	Virginia	600,000
South Carolina	1,500,000		
Texas	1,240,000	Total	[2] 42,440,000
North Carolina	1,000,000		

[1] U. S. Senate Document 443, Sixtieth Congress, first session, "Swamp Lands of the United States," prepared by the Office of Experiment Stations, Department of Agriculture.

[2] The permanent swamp lands of Delaware, Maryland, Tennessee, Kentucky, Illinois, and Indiana where cypress occurs contain about 1,000,000 acres.

It is interesting to note that the area shown in Table 14, much of which is natural cypress land,[1] comprises about 80 per cent of the lands classed as "permanent swamp" and 49 per cent of the entire wet land of all classes in the United States.

All the more valuable southern swamp lands have passed into private ownership. By act of Congress, September 28, 1850, and subsequent enactments, all swamp lands were granted to the various States in which they occurred. For the most part these were in turn sold by the States to private owners. Federal swamp land, unsurveyed and therefore unclaimed by the States, is of exceedingly small area.

[1] In Florida a larger proportion of the area included is nonforested or everglade land.

VALUE OF CUT-OVER SWAMP LAND.

Swamp lands with all the cypress cut out are of rather indefinite value. They are considered mostly unproductive at present and are being held chiefly for their potential value for agriculture after draining and clearing. The scattering stands of associated tupelo gum left on the larger river deltas and narrower stream bottoms have very small stumpage value, while in the slightly higher undulating swamps the oak, ash, and other hardwoods, if of good development, are generally being logged along with the cypress.

In the Mississippi Valley, where a large percentage of the 16,000,000 acres of more or less reclaimed swamp land lies, a figure of $2 to $2.50 perhaps represents fairly well the claimed or speculative value of cut-over cypress swamp lands. Deep sloughs and lagoons fall far below these figures, while "ridges" and higher swamps exceed them in their actual value. A clear distinction should be drawn between *stump* land and *open marsh* land, both of which may be permanent swamp. The equalized average value of denuded cypress lands in Louisiana agreed upon by the State board of equalization for 1913 was $1.50 per acre, while denuded pine land was $2.13, denuded hardwood land $2.15, fresh-water marsh $0.94 to $1.08, and salt-water marsh-land from $0.49 to $0.88 per acre. Some large accessible tracts in Louisiana of black calcareous soil and open marsh are held as high as $10 to $15 per acre. Largely because of the sterility of the acid soils without the addition of lime, and the high cost of clearing the land of the mass of stumps with large heavy roots, the "ponds" and large inland swamps over the lower Atlantic coastal region are at present considered of low nominal value.

COST OF DRAINING AND CLEARING.

The reclaiming of permanent swamp soil for cultivation requires (1) the improvement of natural drainage channels and construction of main ditches or canals—such public drains are made through the cooperation of owners under the provision of State drainage laws; (2) the construction of branches and laterals by the landowners; and (3) the removal of natural vegetation, including stumps. The order in which the various classes of permanent swamp lands will come under reclamation will obviously be governed by the question of cost and relative soil fertility. Open grassy swamps of which there is a large area, will undoubtedly be chosen first in drainage plans, the glades or hardwood ridges naturally drained during a considerable part of the year will follow, and then the *deep* swamps, where cypress finds its characteristic home.

The cost of complete reclamation of stump lands will be very much greater than the average for all lands classed as permanent swamp. The Office of Experiment Stations of the Department of Agriculture

estimates $17 as the average cost per acre of draining permanent swamps.[1] This figure includes public drainage, private drains, and clearing the land for cultivation. Where the original surface is covered with stumps, the additional expense of clearing cut-over cypress land in Louisiana has been found to range from $30 to as high as $100 an acre, depending upon the character of growth.[2] This makes a total expense ranging from $47 to $117, or an average of $82 per acre, for reclamation. If the present value of reclaimed swamp lands and the demand for them is considered, this expense undoubtedly is not justified.

In large drainage projects plans seldom include the reclamation of all the land within the district to be drained. The cost of such work, under present economic conditions, would be altogether prohibitive. Doubtless in some future period the rise of land values will warrant very costly drainage systems. Those cypress lands, which may reasonably be expected to remain to a large degree undrained for many decades, include (1) sloughs and lagoons in otherwise undulating swamp and overflowed land, (2) strips between levees and the normal river channel, (3) entire tracts of deep swamps where cypress grows in pure stands because the land is too wet for other species, (4) narrow marginal swamps along rivers subject to periods of high overflows, and (5) countless small inland "ponds" and dead swamps in flat, poorly drained regions.

VALUE OF RECLAIMED SWAMP LANDS.

The market value of reclaimed swamp lands is generally from $15 to $25 net over and above the cost of the drainage and other work.[1] An expense of $12 an acre for draining, $30 to $100 for clearing, and an initial land value of say $1, plus the operator's profit of $15 to $25, give final values to reclaimed cypress lands ranging from $60 to $140 an acre. This may profitably be compared with the expense of reclaiming wet prairie land, which will include approximately $17 for draining and clearing,[1] $5 to $15 for the land, and the operator's profit of $15 to $25, or a total of $35 to $60. The latter closely approximates current local sale values of drained lands in good condition to produce agricultural crops in the lower Mississippi Valley. Close to good markets, values run above $100 an acre, for intensive use.

This high value of reclaimed prairie land, over and above the cost estimates for an efficient drainage system by conservative engineers, allures capital strongly toward utilizing rich swamp for agriculture.

[1] U. S. Senate Document 443, 60th Cong., 1st sess. Prepared by Office of Experiment Stations, U. S. Department of Agriculture.

[2] U. S. Department of Agriculture, Bul. 71, Office Experiment Stations (Professional Paper), "The Wet Lands of Louisiana and their Drainage."

In the Mississippi Valley, with an overflow area of 50 to 75 miles in width affording millions of acres of very productive soil, this situation is especially emphasized. By comparison, timber growing as an investment has little to offer. It must not be forgotten, however, that a sharp distinction should be drawn between open lands and those covered with a forest of large trees. The perfection of dredging by modern machinery and the possibilities in the control of waters as demonstrated in the Panama Canal and other engineering works, are convincing evidences of the probability of success in the reclaiming of overflow and swamp soils, and have at times led to excessive speculation over tracts promising ready drainage.

In the flush of logging virgin stands of cypress, very little serious consideration has commonly been given to the question of the future use for which the land is best adapted. The largest cypress manufacturers' association in Louisiana has, however, given definite consideration and study to this problem along with the advance of lumbering. Tentatively, their policy is to clean cut cypress lands, having in view their probable early drainage and value for agricultural development, in spite of the high expense of removing the stumps and clearing the lands for cultivation. Consideration of the combined expense of draining and clearing the land, and the distance to markets, will serve to indicate whether or not the investment is a paying one.

It is important in this connection to distinguish clearly between the rich, deep alluvial lands which lie in continuous bodies of extensive area and the numerous small, more or less isolated cypress tracts where drainage features are very different. As a result of large profits realized in the past from draining the open savannas or grassy swamp lands, there is undoubtedly a strong tendency toward a too optimistic view of the early reclamation of deep cypress swamp lands. A large number of operators, convinced that reclamation is certain to be profitable, have decided in favor of taking every cypress tree of possible commercial value and leaving none for future returns.

In reclaiming swamps which are the result of river inundation, the first step of importance is to reduce the amount of overflow. This suggests measures for protecting watersheds against floods, both in the interest of the swamp-drainage system and the preservation of our navigable-stream channels. The long period of time necessary must not be overlooked, since plans for permanent reclamation call for an orderly progression of the work in accordance with the need for the land, market conditions, and transportation facilities. The information available regarding the rate of growth of second-growth cypress trees and stands and the effect of drainage upon growth (see pp. 39 to 46) will be helpful to the owner of cypress land in arriving broadly at conclusions regarding its comparative future value for agriculture and timber production.

AIM AND METHOD OF FOREST MANAGEMENT.

Forest management is not nearly so well understood as farm management, although the object of each is the same; namely, to secure the highest financial returns from the class of land involved. With the cutting of the virgin stands, timberlands become available for further productive use for the purpose to which they are best adapted from a financial standpoint. Many tracts of forest, particularly in the Northeastern States, are bing handled with a view of securing the largest continuous yield of timber of the most valuable species. This is the aim of forest management.

To cut the mature timber in such a manner as to secure its fullest utilization, and, following logging, to obtain complete stands of young seedlings as the basis for the next crop, are the chief objects to be attained by properly handling forests. In places where natural reproduction fails, the stand may be filled out by sowing seed or planting seedlings raised in nursery beds. Protection of the growing trees against various forms of injury and further assistance of the trees in their growth by proper thinning are important steps in attaining the desired end.

Forest management of cypress deals with the proper handling of present supplies rather than with the extension of the species on a general scale. For various reasons cypress does not promise to be one of the main contributors of the country's future timber supply. Forest management of cypress in the future will consist chiefly of (1) the conservative cutting and close utilization in logging of the present virgin stand, (2) in many cases the retention and protection of the younger growing timber, and (3) manufacturing so as to secure the largest production of the best grades.

PROFITABLENESS OF FOREST MANAGEMENT.

In logging virgin cypress timber, the question inevitably arises whether it is profitable to leave the younger portions of the stand for a second cut. For example, if a cypress stand cut clean at the present time will yield $10,000 net profit, will it pay the owner to take four-fifths of the merchantable timber at the present time, consisting of the larger classes and yielding a net profit of $9,000, and postpone the returns on $1,000[1] until the time of a second cut?

In favor of holding a portion of the timber for the second cut are the following: The increased local demand for timber resulting from the establishment of new industries in the South, the faster growth of the timber left standing from the first cutting, and the excessive cost of clearing and draining deep swamp land covered with stumps and roots. Under these conditions it will undoubtedly in many instances be good business to leave cypress trees below a specified diameter limit,

[1] Small sizes are expensive to log and yield little if any net profit.

for example, 18 to 24 inches on the stump, where present cutting takes everything down as low as 12 to 14 inches. Natural conditions favorable to a deferred second cut may be found (1) in stands of mixed ages with good representation of younger groups of cypress; (2) where logging will be repeated in a decade or two in order to remove good stands of hardwoods not at present merchantable; (3) where the fixed cost of logging is low, as in float logging; and (4) in the present very low producing power of the land for any other purpose than timber growing.

There are several classes of cypress lands (see pp. 21–22) which are not likely to be reclaimed and put under cultivation for many decades, if ever. These situations are mostly subject to deep overflows and thus permit float logging, which is the least expensive and the most practical form of follow-up logging for second-growth cypress lands in the future. The associated "ridges," or better drained portions of the swamp, characterized usually by mixed hardwoods with scattering mature cypress, in the orderly progression of swamp reclamation will earlier come under drainage and farm management. This distinction between the relative heights of different levels of the swamp and their respective future uses, it is believed, is commonly given too little consideration in connection both with plans for reclamation projects and with the conservative cutting and management of cypress stands.

In many swamps good stands of the more valuable hardwoods have been left, such as oaks, ash, and gums, which will be removed in the course of from 10 to 25 years. Many large operators intend to go back later over the old cutting areas and log timber which was unmerchantable at the time of the first cutting. Here the practice of clean cutting of cypress down to include the young vigorous trees would be, from a purely financial standpoint, unquestionably a mistake. These trees are rapidly increasing in size and should be left for a later logging. Float logging, where the investment and cost of logging are low, permits of conservative cutting and an approach to a sustained yield of timber by selecting the trees on the basis of a minimum diameter limit.

In favor of clear cutting is the fact that there are a large number of lumbering plants in the South which promise from 6 to 8 per cent returns on safe investments. In comparison with these opportunities, the uncertainty of the lumber market 20 or 40 years hence discourages delay in harvesting the available crop, especially if present owners bear in mind the qualifications of Pacific coast lumber for competition with cypress and the extent to which its use will increase in the eastern market as a result of the opening of the Panama Canal and other causes. The increasing use of various substitutes for wood is another factor to be taken into consideration.

Whether forest management will prove profitable and is therefore advisable depends largely upon (1) the rate of growth and various other characteristics of the species; (2) capital represented by the land and growing timber; (3) cost of establishing, protecting, thinning, and other operations in the stand; and (4) the final money values of the timber crops produced.

Clear cutting is generally advisable where the land now commands or promises soon to command, a high value for farm use, where the stand of cypress is practically pure and mostly mature without clumps of young growth, and where logging costs are very high.

ADAPTABILITY OF CYPRESS TO MANAGEMENT.

The leading characteristics of cypress which bear upon its suitability for management are:

(1) Cypress inhabits permanent swamps much too wet for agriculture and most other uses, except when drained at a large and sometimes prohibitive cost. It is adapted and valuable, therefore, for utilizing large areas of otherwise unproductive swamp land.

(2) In exposures open to light, the rate of growth greatly exceeds that of virgin stands, and on similar sites is comparable with the growth of red gum, ash, and other more common hardwoods; crowded stands thin themselves slowly and growth is moderate unless helped by thinning for pole, tie, or other classes of small timber.

(3) It is inherently a vigorous tree with few emenies, is readily grown from seed, and, judging by experience and observation, may be planted out with good results when 1 or 2 years old.

(4) Cypress is well adapted for growing in pure, even-aged stands. This form of stand is economically favorable because of the difficulties and high expense of logging, except where water transportation is available.

(5) Although cypress makes its best growth on deep, well drained, fresh or moist loamy soils, on account of inherent restrictions it practically never reproduces itself there. It reproduces and permanently maintains its position as the dominant tree of the stand only in extremely wet situations. Since the higher swamp areas are more easily drained and will be the first to be utilized for farm crops, the "ridge type" of hardwood lands will be permanently replaced sooner than typical cypress lands in the reclamation of swamps.

(6) Natural reproduction, following the earlier cuttings by the selection system, is generally good, and this method promises well wherever sufficient seed trees have been left. Clear cutting in virgin stands results in poor restocking.

These several qualifications indicate both the demands to be met and the relative position to be occupied by cypress in the future forests of the South.

LOW VALUE OF LAND AND GROWING STOCK.

It has been shown (p. 52) that uncleared and undrained lands covered with stumps and a mass of surface roots are of low and generally uncertain value, and that the cost of draining and clearing is somewhat more than the present value of similar cleared and drained lands. The actual present value of the timber left on the land after conservative cutting is very small compared with its potential value.

The figures given in Table 15 apply to the cypress in a typical mixed cypress and hardwood stand, cutting an average of approximately 12,500 board feet of cypress per acre. This is a safe average for medium mixed cypress, since pure cypress often cuts from 15 to 25 thousand board feet over large areas. It should be noted that the volume of the trees 16 inches and over in diameter constitutes 94 per cent of the stand. By cutting to a diameter limit of 18 inches, the amount of merchantable timber left standing on the average will likely amount to between 8 and 10 per cent of this particular stand. In other stands not so well stocked with younger classes it will be less.

TABLE 15.—*Cypress trees by diameter classes and corresponding volumes in a representative stand.*[1]

Diameter (breast-high).	Trees per acre.	Volume per acre (Doyle rule).		Per cent of total stand.
		Average tree.	Total stand.	
Inches.		*Board feet.*	*Board feet.*	
1 to 5	16.0			
6 to 10	11.0	4	44	0.3
11 to 15	9.8	72	706	5.7
16 to 20	8.2	200	1,640	13.1
21 to 25	5.4	413	2,230	17.9
26 to 30	3.9	760	2,964	23.8
31 to 35	2.0	1,121	2,242	18.0
36 to 40	1.4	1,476	2,066	16.6
41 to 45	.2	1,821	364	2.9
46 to 50	.1	2,160	216	1.7
Total	58.0		12,472	100.0

[1] Cypress in mixture with hardwoods (about one-third of the latter); 21 trees per acre of cypress 16 inches and over in diameter. Representative of large tracts in Florida and Louisiana.

In the above representative stand with a good stocking of young trees, 5.7 per cent of the volume is contained in the trees from 11 to 15 inches in diameter. A diameter limit of 16 inches in this stand would mean leaving approximately 750 board feet, or a value of $3.75, at an average stumpage rate of $5 per thousand feet. The combined value of land and timber left in cutting to a 16-inch diameter limit will probably average generally between $4 and $7 per acre.

Lumbermen in very many cases fail to consider fairly the very low relative stumpage value of timber in the small sizes. Small trees obviously are utilized at relatively little profit, or often at a loss,

because of the high expense in handling and the low grade of the product. The percentage of increase in volume is relatively much greater in trees from 10 to 18 inches in diameter than in larger trees.

COST OF PROTECTION, THINNING, ETC.

The holding of a small portion of the virgin stand for a second cut entails no essential additional outlay. Fire menace is at a minimum, and no other form of damage requires attention, including timber trespass and grazing. In case planting is done to fill in blank spaces, an additional expense of between $4 and $10 per acre must be reckoned. A detailed account is given on pages 67 to 69.

VALUE OF CROP PRODUCED.

Cypress trees from 15 to 18 inches in diameter left on cut-over land in southern Louisiana,[1] measured in 1908, 1910, and 1913, were found to be increasing in breast-high diameter at the rate of an inch in a little over two years. Trees of the younger classes on cut-over lands will be stimulated in growth by the admission of additional light. Table 16 shows the average volume in board feet for cypresses of various diameters, also the corresponding increase in volume for each increase of 1 inch in breast-high diameter. For example, a 15-inch cypress contains 23 board feet more than a 14-inch tree. If the rate of growth is an inch in diameter in 3 years, the volume of the tree is increasing 8 board feet a year. Growing at the same rate, an 18-inch tree adds about 10 board feet, and a 24-inch tree 20 feet annually. A slower growth of 1 inch in 4 years will give slightly decreased figures. It is known that the rate of diameter growth remains about constant in cypress for the sizes shown in the table.

TABLE 16.—*Rate of increase in volume for second-growth cypress trees, 10 to 24 inches in diameter (Southern United States).*

Diameter breast-high.	Volume of tree (Doyle rule).	Increase in volume from preceding diameter class.		Annual rate of increase in volume.		
				Rapid growth (1 inch increase in 3 years).	Moderate growth (1 inch increase in 4 years).	Slow growth (1 inch increase in 6 years).
Inches.	*Board feet.*	*Board feet.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
10	20					
11	37	17	85	28.3	21.2	14.2
12	54	17	46	15.3	11.5	7.7
13	72	18	33	11.0	8.2	5.5
14	92	20	28	9.3	7.0	4.7
15	115	23	25	8.3	6.2	4.2
16	141	26	23	7.7	5.8	3.8
17	169	28	20	6.7	5.0	3.3
18	200	31	18	6.0	4.5	3.0
19	234	34	17	5.7	4.2	2.8
20	271	37	16	5.3	4.0	2.7
21	312	41	15	5.0	3.8	2.5
22	359	47	15	5.0	3.8	2.5
23	413	54	15	5.0	3.8	2.5
24	473	60	15	5.0	3.8	2.5

[1] Belle River, Grand River Basin, St. Martins Parish, La.

The approximate annual money increment of the tree may be readily calculated by multiplying the number of board feet the tree is producing annually by the current stumpage rate. Thus, at $5 per thousand board feet,[1] the trees in Table 16 are increasing in value annually at the rate of about 4 cents each for a 15-inch tree, 5 cents for an 18-inch tree, and 10 cents for a 24-inch tree. This indicates also the increasing rate of annual money returns from trees of large size. By ascertaining the number of trees of each diameter group and applying to them the figures shown in Table 17, the total increase of the stand may be obtained in round numbers. Average annual increases in value of about $4 per acre represent approximately the enhancement of a stand of 100 trees per acre of an average present size of 15 inches, growing at the rate of 1 inch in diameter in 3 years; at a slower rate of 1 inch in 4 years the increase will be about $3 per acre.

In the absence of yield tables, which are difficult to obtain in the uneven or all-aged cypress stands, the above calculation, based upon Table 17 and volume and stand tables, may be used as a satisfactory approximation of the increasing value of young growing cypress.

In the representative stand used for illustration (p. 57), approximately 750 board feet or 6 per cent of the total volume would be left if the original stand were cut to a 16-inch diameter limit; if cut to an 18-inch limit about 10 per cent of the stand would remain.[2] Growing at the rate of 1 inch in 4 years, the trees left will increase 5 inches in diameter in the next 20 years, reaching the next higher diameter class of 16 to 20 inches. Allowing 10 per cent loss in numbers for death and permanent injury, there will then be about 9 merchantable trees per acre, from 16 to 20 inches in diameter, with a total volume of 1,800 board feet.[3] This is an increase of 1,050 feet, or 140 per cent. A stumpage rate of $5 per thousand feet gives a total value of $9, or an increase of $5.25. If the stand is cut to an 18-inch minimum limit, about 1,250 board feet will be left, valued at $6.25. In 20 years the 12 trees will increase by about 1,810 feet, or approximately 145 per cent, and be worth $15.30. Stumpage in 20 years may be higher than $5, but only present values are used in these calculations.

If these figures of money yield do not appear attractive as compared with other forms of investment, the unproductive character of the land except for timber growth must not be overlooked.

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[1] Good grade of second-growth cypress.

[2] Based upon Table 20.

[3] Based upon Table 15.

TABLE 17.—*Increase in board feet and money value in 10, 20, and 30 years for cypress trees of various diameters, at stumpage price of $5 per thousand feet.*

	Tree diameter (breast high) (inches).											
	12			14			16			18		
	Rate of growth (years required for 1 inch increase in diameter).											
	3	4	6	3	4	6	3	4	6	3	4	6
Present volume of tree (board feet)	54	54	54	92	92	92	141	141	141	200	200	200
Annual increase in volume	5.7	4.2	2.8	6.7	5	3.3	8.7	6.5	4.3	10.3	7.8	5.2
Volume in 10 years	111	96	82	159	142	125	228	206	184	303	278	252
Volume in 20 years	168	138	110	226	192	158	315	271	227	406	356	304
Volume in 30 years	225	180	138	293	242	191	402	336	270	509	434	356
Present value of tree	$0.27	$0.27	$0.27	$0.46	$0.46	$0.46	$0.70	$0.70	$0.70	$1.00	$1.00	$1.00
Annual increase in value	.028	.021	.014	.034	.025	.016	.044	.032	.022	.052	.039	.026
Value in 10 years	.56	.48	.41	.80	.71	.62	1.14	1.03	.92	1.52	1.39	1.26
Value in 20 years	.84	.69	.55	1.13	.96	.79	1.58	1.36	1.14	2.03	1.78	1.52
Value in 30 years	1.12	.90	.69	1.46	1.21	.96	2.01	1.68	1.35	2.54	2.17	1.78

	Tree diameter (breast high) (inches).								
	20			22			24		
	Rate of growth (years required for 1 inch increase in diameter).								
	3	4	6	3	4	6	3	4	6
Present volume of tree (board feet)	271	271	271	359	359	359	473	473	473
Annual increase in volume	12.3	9.2	6.2	15.7	11.8	7.8	20	15	10
Volume in 10 years	394	363	333	516	477	437	673	623	573
Volume in 20 years	517	455	395	673	595	515	873	773	673
Volume in 30 years	640	547	457	830	713	593	1,073	923	773
Present value of tree	$1.36	$1.36	$1.36	$1.80	$1.80	$1.80	$2.36	$2.36	$2.36
Annual increase in value	.062	.046	.031	.078	.059	.039	.10	.075	.050
Value in 10 years	1.97	1.82	1.66	2.58	2.38	2.18	3.36	3.12	2.86
Value in 20 years	2.58	2.28	1.98	3.36	2.98	2.58	4.36	3.86	3.36
Value in 30 years	3.20	2.74	2.28	4.15	3.56	2.96	5.36	4.62	3.86

TREATMENT OF VIRGIN STANDS.

From the lumberman's standpoint the first aim in cutting virgin stands should be the complete utilization of the material taken. Close utilization of the tops and butts has been practiced for some years in Louisiana, and there seems no good reason why this would not be equally profitable along the southern Atlantic Coast, where lower transportation rates are offered to the central market region in the northeastern States.

Too often customs from the earlier and more primitive logging days survive tenaciously, in spite of advancement and change in economic conditions which make complete utilization of trees profitable. Considering the high value of cypress stumpage, it is believed to be an actual loss under ordinary conditions to leave high stumps and large sound tops. Felling the trees at the height at which they have been girdled usually results in heavy waste of sound timber.[1]

[1] Girdling is done at a high point to avoid unnecessary labor.

The stumpage value of material left in high stumps will often pay for felling and cutting up the tree. Complete utilization brings down the fixed or overhead expense, leaving the operating cost alone to furnish the basis for figuring the profit or loss of taking out the individual material. This distinction, it is feared, is not clearly drawn by the average operator. The installation in the main mill of a small circular saw with 3-man crew to work up logs from small trees, top logs, and others of low grade has been suggested as feasible in mixed sizes and under ordinary conditions.[1] Logs of this class tie up a big saw crew and by reducing the daily output increase correspondingly the cost of manufacture.

The second aim in cutting virgin stands should be the welfare of the succeeding timber crop, to be secured by early and complete restocking of the tract. It will be clearly understood that this applies only to situations which promise to remain either permanently or for a long period as swamp land.

The essential requirements for satisfactory reproduction in virgin stands are sufficient seed trees and openings to light. The vigorous smaller trees, left because they are increasing at their most rapid rate both in size and money value, will produce seed of the highest quality though limited in quality. The stand might be cut to a minimum diameter of 18 inches at breast height. A tree of this size gives a butt log from 12 to 14 inches in diameter at the top end. In virgin stands such trees vary from 130 to 170 years old and in second-growth or open-grown stands from 65 to 90 years. For the best results in reproduction it is desirable to leave standing on the tract not less than from 4 to 8 trees per acre, from 10 to 18 inches in diameter. The practice of felling overmature trees which clearly contain no merchantable cypress timber is beneficial in clearing up the area of pecky fungus, but undersirable where a deficiency in younger seed trees exists. Old trees quite regularly produce crops of seed, which, although less desirable, may be needed for restocking the ground.

Millions of young cypress trees are cut indiscriminately for such uses as raft binders, car stays, mud sills, and cribbing logs on temporary lines, where the ordinary hardwoods would answer the requirement and should be taken in preference to young cypress. Some conservative operators in Florida are requiring attention on the part of their employees to the protection and encouragement of cypress reproduction and young trees. Groups or clumps of such trees are often unnecessarily injured in felling large trees; in some cases skidder sets and logging spurs may just as well be located in other places. The removal of the hardwoods should be accomplished to as full a degree as possible in order to make openings for the more valuable cypress

[1] To be located in the space beyond the main saw.

and reduce the competition for light. Heavy openings without adequate seed trees contain a rank undergrowth of saw grass, cattails, iris, and various shrubs, but the same openings supplied with an abundance of cypress seed will start a new timber crop.

Groups or small stands of polewood cypress occurring in virgin stands should be thinned in order to give the better individuals increased space for crown development, as well as root space if subject to acid water or periods of summer drought.

CUT-OVER CYPRESS AREAS.

It is doubtful if any operations toward the improvement of old cut-over cypress tracts will pay for themselves. Reproduction following the early cuttings has generally been good. On one logged tract in Iberville Parish, La., an average of 340 cypress trees per acre 20 to 30 years old, were counted.[1] Plate V shows saplings filling in small openings in the stand. Since the general introduction of overhead cableway skidders and the resulting very clean logging of cypress, the possibility of a future cypress stand has been practically eliminated from several million acres. The complete removal of a mature virgin cypress stand without making provision for the succeeding crops is giving results similar to those from the clean cutting of virgin stands of white and longleaf pines. The rank growth of shrubs and vines and the sprout reproduction in mixed cypress and hardwood cuttings makes it doubtful whether the expenditure of money for reforestation would bring a profit, especially when the uncertainty about future uses of the lands is considered.

CARE OF YOUNG STANDS.

Thinning is one of the few operations to be considered in dense young second-growth stands. The characteristic cypress "ponds" and shallow swamps over the coastal plain contain pure stands of cypress of comparatively small size, including a good deal of young growth. Much of the suppression of young trees in groups can be overcome by thinning and improvement cutting. In some cases this will be profitable, although in others the materials removed will not repay the expense of thinning. Only in the former case should the operation be attempted. There are two methods of thinning: (1) Removing the smaller trees which are crowded or overtopped by their larger neighbors, and (2) taking out the larger dominant, and "wolf" trees which suppress the growth in several adjacent trees of average size. Because of the all-aged character of cypress stands, the first method will generally give better results, varied occasionally by the removal of one or more dominant trees from a group in order to benefit adjacent trees by affording light and perhaps root space. After thinning, the new growth will be distributed among fewer individual

[1] By McLean, F. T. Manuscript report on cypress, Forest Service, 1908.

trees and will produce a higher average grade of timber. Since cypress seeds frequently and in good quantity, seedlings may be expected to fill in the blank spaces left.

Thinning or selective cutting for ties, poles, etc., or taking the larger trees down to a diameter limit of from 14 to 18 inches, can be practiced as a rule in ponds and small inland swamps, because of their accessibility during fall dry weather, and the ease with which small skidding engines mounted on runners can be moved and set up along their margins. On account of unfavorable conditions, growth is relatively slow in shallow undrained cypress ponds.

PROFITABLENESS OF GROWING CYPRESS POLES.

The profitableness of growing cypress on short rotations, reckoning on the basis of present prices, promises a rather better showing for poles than for ties and possibly also than for saw timber.

In 60 years second-growth cypress trees will yield poles 30 to 32 feet long, 6 inches at the top and about 14 inches at the butt. Such poles are worth in stumpage from 25 to 50 cents apiece. In 100 years 40-foot poles about 8 inches at the top end are obtained, worth at present about $1 each in the tree. Average well-stocked, pure stands, 50 to 75 years old, contain approximately from 250 to 350 trees per acre. The stumpage value in poles at current prices will amount to $75 to $150 per acre at 60 years, or $200 to $300 at 100 years. Figuring on a 60-year rotation:

Value of land, $2.50 [1] per acre, compounded at 6 per cent annually for 60 years	$82.48
Taxes at 2 cents annually compounded for 60 years at 6 per cent	10.66
	93.14

This indicates the profitableness of holding young cypress for poles on lands, with an average value of $2.50 per acre and assessed at 60 per cent of their real value. At a stumpage production of $100 an acre for fully stocked natural stands a profit of a little over 6 per cent, compounded annually, will be realized at the end of 60 years. In case artificial stocking is necessary by planting seedlings, costing $6 an acre, on land valued at $2.50 per acre, the same crop will produce a net profit on the total investment of about 4 per cent, compounded annually.

From the values given above it is clear that growing cypress poles on a 100-year rotation would be less profitable, even starting with fully stocked natural stands, than on a 60-year rotation. Similar calculations indicate that it would be comparatively unprofitable to grow ties except for the reduced cost of getting them to market. The promise of success in growing cypress is greater on small tracts near local markets and also where water logging is possible.

[1] About 1.7 times the assessed taxation value of $1.50 per acre.

PLANTING AND SOWING CYPRESS.

The establishment of young stands by sowing or planting will probably always be of limited application in the case of cypress. On a small scale, however, where it is desired to devote wet or moderately moist lands to their highest form of timber production, the planting of cypress in the Eastern and Southern States will unquestionably be practicable. Experiments and nursery practice seem fully to establish the adaptability of cypress and the success of the method.

CYPRESS UNDER CULTIVATION.

In many parks, lawns, and arboretums of both Europe and the United States cypress has proved to be a hardy and rapid growing tree. When grown in the open, its habit resembles that of eastern red cedar, but it is somewhat more cylindrical. On account of its light, feathery foliage and narrow pyramidal shape cypress is a tree of distinctive appearance and striking beauty. (See Pl. XII.)

Commercially, cypress is being increasingly planted on account of its good rate of growth and the value of its wood. In the last few years 75,000 seedlings have been planted in Ohio under the general direction of State forestry organizations. The older cypress plantations in Ohio are reported by the State forester[1] as having made a satisfactory record in the production of timber. The potential range for planting appears to reach as far north as the southern portions of New England, New York, and Michigan. Individual trees will grow somewhat farther north, but when young are susceptible to injury by freezing.

Cypress does not require, as is usually believed, heavy, wet, swamp soils. It does not thrive in hot, dry situations or in pure sand, but does well in ordinary loamy, calcareous, and clay soils, which as a class are retentive of moisture. The requirements of cypress call for the more favorable class of hardwood sites, including moist slope and bottom land, typical soil for such species as beech, maples, basswood, tulip poplar, catalpa, elm, oak, sycamore, and cottonwood. Trees in the District of Columbia are growing well near the Potomac Flats (Pl. XII) and also on Meridian Hill, about 200 feet in local elevation above the river. Because of previous good results the city of Cincinnati in 1914 planted 40,000 cypress seedlings in forest stands on relatively high, well-drained ground.

GROWTH OF PLANTED CYPRESS.

The rate of growth of individual planted cypress trees is closely comparable to that of the more rapid hardwoods. Under cultivation trees grow from 18 to 24 feet in height in the first 10 years. The best

[1] Edmund Secrest, State Forest, Wooster, Ohio.

PROGRESSIVE STAGES IN THE DEVELOPMENT OF CYPRESS SEEDLINGS.

Seed at beginning of series and cone or "ball" in upper left-hand corner. (Seven-ninths natural size.)

CYPRESS ON GROUNDS OF U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

The center tree measures 74 feet in height by 21 inches in diameter (breasthigh), and the group was planted about 1868, so the trees are about 50 years old.

height growth in Ohio, for example, has been 3 feet annually for a few years. In fresh or moist soil west of Columbus, some cypress trees are growing 30 inches a year in height. In dry situations, such as eroded clay hillsides and in loose gravelly soils, growth is less than a foot a year. In the District of Columbia cypresses 50 years old are from 20 to 30 inches in diameter by 65 to 84 feet in height, excelling all associated species in rate of height growth. Measurements on growth in forest plantations are not available, but observations show a good development of cypress in height and diameter when properly spaced in planted stands.

NURSERY PRACTICE.

Cypress may be grown from seed in nursery beds as successfully as many of the common conifers.

The structure of the seed and germination tests described on pages 29 to 30 indicate certain requirements of moisture and heat that should be carefully followed for the successful and economical germination of cypress seeds. Among these are (1) the softening of the seed coats, making it advantageous to soak cypress seeds in water (apparently from four to six weeks[1]) prior to sowing in the seed bed; (2) the requirement of a rather high degree of heat for germination, making it advisable to sow seeds in late spring or early summer, when a good degree of heat is present. Undoubtedly the highest germination can be secured by sowing in a protected hotbed or greenhouse, although this method is not necessary. The soil should be kept well supplied with moisture. Mulching will be an effective aid.

Some nurserymen store the seed where they will be cool and moist over winter. Stratification will accomplish this, and moderate freezing is said not to injure the seed. The requirements for germination are warmth and continuous moisture, both in greater abundance, however, than is required by some of the upland pines. Light mulching of seed beds is often very helpful. Prof. J. W. Toumey, of the Yale Forest School, states that cypress seed sown outdoors at New Haven, Conn., in the spring germinates freely in about six weeks, with about 40 per cent germination. Cypress resembles the hardwoods in requiring a deep loamy soil. Sowing the seed in drills in seed beds permits of light cultivation of the soil, while broadcasting better utilizes seed bed space.

Clean seed averages about 5,000 to the pound. Commercial seed is not cleaned but contains from 25 to 40 per cent by weight of cone scales[2] (fig. 6) and sells usually at 75 cents to $1 a pound. The

[1] Comparative tests have not been made on duration, character of water, whether stagnant or fresh, etc., in this preliminary treatment of cypress seed.

[2] See p. 29 for further description of seed. Since the cone scales are only slightly larger than the seed, separation is not attempted, which accounts for the trash contained in commercial seed.

actual cost of collecting seed from the trees where logging is in operation is considerably less. The month of October is the most favorable time for collecting seed, which should be done before the cones ("balls") are sufficiently ripe to open or fall off when the tree is felled. Where no logging is in progress seed may be gathered by climbing moderate-sized trees where cones can be reached by hand. Lineman's climbers are useful in this operation. Various devices may be used for collecting the cones beyond arm's length. After being picked the cones should be spread on trays, screen, canvas, or tight floors to dry.

Young seedlings show exceptional vigor and are transplanted with the greatest ease, provided soil moisture is plentiful. The root system is comparatively shallow. In the dryer natural situations the tap-

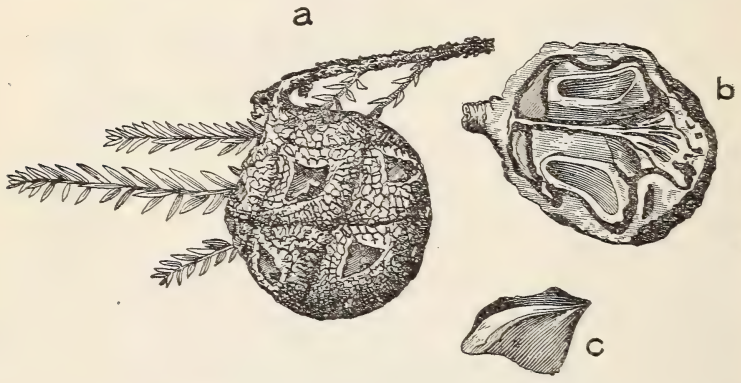

FIG. 6.—Cypress cone and seed: *a*, Fruiting branchlet; *b*, section of cone showing two of the seed; *c*, seed (about natural size).

root even in young saplings has been found to extend downward for several feet. In the dryer nursery soils it is essential to supply abundant moisture, and mulching will prove very helpful. Additional growing space may be required if the seedlings are kept in the nursery during the second season. If the seedlings are transplanted in the nursery, a spacing of 2 to 4 inches in rows 4 to 8 inches apart will probably be about right in most soils during the second season.

The hardiness of cypress seedlings in the Northern States depends somewhat on where the seed was grown. Louisiana and Florida seed, for example, have been found to produce seedlings less able to stand the cold winters than seed from the more northern portion of the range.[1] The amount of seed from more northern regions is limited, however, by the failure of cypress to mature seed to any considerable extent over the extreme northern portion. At New Haven, Conn., it has been found impossible to collect fertile seeds from trees growing in the locality, while perfectly hardy cypresses have been grown from

[1] Toumey, J. W., Yale Forest School, New Haven, Conn.

seed collected farther south. Experiments seem to show that seed from the slow-growing "pond" form of cypress will produce inferior stock to that grown from seed from thrifty trees favorably situated. Because the poorer seed is much more accessible, it is apt to find its way freely to the market. No point of difference is known by which to distinguish seed from the two or more botanical forms.

PLANTING.

Practically all experience points to the general hardiness and adaptability of cypress for planting in forest stands. The best time for planting appears to be during late fall or early winter, so that the seedlings can become established during the subsequent period of low water. Planting in the spring should be done just before the buds begin to swell. Although leafless in winter, like the hardwoods, cypress requires care in handling in keeping the roots always moist and the fine rootlets as intact as possible; in this respect, cypress appears intermediate between the hardwoods and ordinary conifers.

Seedlings are best transplanted at the end of the first or second year; the older and larger stock will be found preferable for tracts inundated for periods of considerable duration. One-year stock will likely be found satisfactory in ordinary situations. Cypress seedlings are semiaquatic and will grow standing in shallow water.

Since the foliage is browsed, protection against grazing animals when closely confined is necessary in order to avoid injury to plantations.

Because of the small amount of cypress that has been planted, evidence based upon measurements can not be furnished to show the financial results to be expected. Hence it is impossible at this time to offer any definite recommendations in regard to the advisability of planting cypress on a commercial scale.[1] Material of the sort needed to form a basis for such recommendations will become available with the further development of young planted stands, and additional experience in methods of planting.

The central Mississippi, Ohio Valley, and middle Atlantic coast regions offer promise of being well adapted to commercial planting. As with all species of trees, the profitableness depends essentially upon various local conditions after all questions of growth and general adaptability of the species from a silvicultural standpoint have been settled. Planted cottonwood, for example, has proved to be profitable on some of the heavy, less valuable bottoms of the central Mississippi Valley.[2] Unless treated, however, its wood is very short lived in contact with the soil, while the heartwood of cypress is very durable, and therefore well fitted in this respect for such uses as posts,

[1] Ohio is taking the lead above all others in planting cypress. Address the State Forester, Wooster, Ohio.

[2] Bull. 24, U. S. Dept. of Agr., "Cottonwood in the Mississippi Valley."

poles, and ties. In the Southern States the problem of utilizing the cut-over swamp land to the greatest advantage involves the question of planting cypress.

The cost per thousand of growing cypress in lots of 100,000 seedlings is estimated as follows:

One-year seedlings	$3.00 to $4.00
Two-year seedlings	3.75 to 5.00
Two-year stock (one-year transplanted)	5.00 to 6.50

The expense of planting the seedlings in their permanent situation will vary with the distance from the nursery, the character of the soil, whether soft or moderately firm, and the spacing used. The

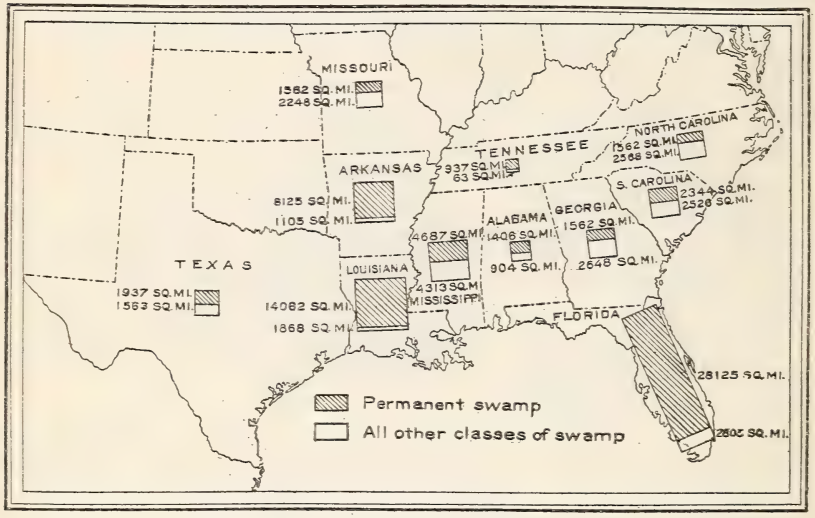

FIG. 7.—Areas of permanent swamp in the United States.

cost of planting per thousand, including transportation, should be about as follows: [1]

One-year seedlings	$2.75 to $4.00
Two-year seedlings	3.25 to 5.00
Two-year stock (one year transplanted)	4.50 to 6.50

Unless the land is entirely cleared, which seldom occurs, it is not desirable to plant an entire acre with a regular spacing. In planting open places it may be advisable to use a close spacing, but on the whole a tree every 8 feet in either direction should be sufficient.

[1] This estimate is based on the production of 100,000 seedlings a year. Increasing the size of the operation noticeably decreases the cost per thousand. While growing a smaller number usually increases the cost, the farmer is often in a position to collect seed and raise five to fifteen thousand cypress seedlings in garden soil at very little expense.

Under average conditions the total cost per acre of growing and planting nursery-grown cypress stock of different ages and with different spacing will be about as follows:

Kind of stock.	Spacing.		
	10 by 10 feet (436 per acre).	8 by 8 feet (680 per acre).	6 by 6 feet (1,210 per acre).
One-year seedlings	$3.10 to $3.60	$4.50 to $5.00	$7.40 to $8.60
Two-year seedlings	3.80 to 4.50	5.40 to 6.30	9.30 to 10.80
Two-year stock (one-year transplanted)	4.70 to 5.80	7.00 to 8.00	12.00 to 16.00

The situations where the most intensive classification and development of southern swamp lands is likely to make forest planting of cypress feasible are (1) large tracts of permanent swamp covered with stumps, under the ownership of a strong permanent organization, either private or public; and (2) small areas, near good markets with transportation facilities, which it is desired to manage intensively in connection with other business such as farming.

APPENDIX.

TABLES.

VOLUME.

Tables 18 to 21, inclusive, show the volume in board feet for cypress of different diameters measured at breastheight (4.5) and at 20 feet from the ground, or about the top end of the first 16-foot log.[1]

TABLE 18.—*Volume in board feet of cypress by Doyle log rule, based upon diameter at 20 [2] feet and number of logs in tree (Maryland and South Carolina).*

Diameter of tree at 20-foot above ground[3].	Number of 16-foot logs.						Height of stump.	Average length of log.	Diameter (inside bark) of top.	Basis.
	1	2	3	4	5	6				
	Volume—board feet.									
Inches.							*Feet.*	*Feet.*	*Inches.*	*Trees.*
8	15	25	35	45	.....	.....	2.3	13	6	14
9	25	35	50	65	.....	.....	2.4	14	6	12
10	35	50	65	85	100	.....	2.5	14	7	20
11	55	75	90	115	140	.....	2.6	15	7	21
12	75	100	125	150	175	.....	2.7	15	8	19
13	100	125	160	190	220	250	2.8	15	9	18
14	125	160	195	240	280	330	2.9	15	9	15
15	145	195	240	290	340	390	3.0	16	10	21
16	.....	230	290	340	400	470	3.1	16	10	37
17	.....	280	340	400	470	540	3.1	17	11	28
18	.....	330	400	480	550	630	3.2	17	12	34
19	.....	390	470	560	640	730	3.3	17	13	22
20	.....	460	550	640	740	850	3.4	17	14	19
21	.....	520	630	740	850	970	3.5	18	15	22
22	.....	590	710	840	970	1,110	3.5	18	16	30
23	.....	660	800	950	1,110	1,280	3.6	18	17	20
24	.....	730	890	1,070	1,260	1,460	3.7	18	18	23
25	.....	800	990	1,200	1,410	1,630	3.7	18	19	14
26	.....	870	1,090	1,330	1,570	1,830	3.8	18	20	19
27	.....	950	1,200	1,460	1,730	2,000	3.8	19	21	12
28	.....	.....	1,300	1,600	1,900	2,200	3.9	19	23	5
29	.....	.....	1,410	1,730	2,060	2,400	3.9	19	24	7
30	.....	.....	1,520	1,870	2,230	2,600	4.0	19	25	5
										437

[1] Since the form of tree growth is apt to vary somewhat under widely different climates and soils, volume tables are usually considered more or less local in their application. In the case of cypress, however, since wide differences in growth appear to be present within any specific locality, volume tables for cypress for one region are generally applicable and may be used for other portions of its commercial range.

[2] Top of first 16-foot log in larger trees.

[3] Measured outside bark.

TABLE 19.—*Volume in board feet of cypress by Scribner log rule, based upon diameter (at top of first 16-foot log) and number of 16-foot logs in tree (Maryland and South Carolina).*

Diameter[1] at 20 feet.	1 log.		2 logs.		3 logs.		4 logs.		5 logs.		Basis.
	Volume.	Diameter inside bark of top.	Volume.	Diameter inside bark of top.	Volume.	Diameter inside bark of top.	Volume.	Diameter inside bark of top.	Volume.	Diameter inside bark of top.	
Inches.	*Bd. ft.*	*Inches.*	*Bd. ft.*	*Inches.*	*Bd. ft.*	*Inches.*	*Bd. ft.*	*Inches.*	*Bd. ft.*	*Inches.*	*Trees.*
6	20	6.0	.....	.....	.....	.....	.....	.....	.....	.....	6
7	25	6.8	.....	.....	.....	.....	.....	.....	.....	.....	3
8	30	7.7	55	6.2	.....	.....	.....	.....	.....	.....	7
9	40	8.7	70	7.0	100	6.1	.....	.....	.....	.....	12
10	.....	.....	85	8.0	120	6.8	.....	.....	.....	.....	20
11	.....	.....	105	8.9	145	7.6	.....	.....	.....	.....	20
12	.....	.....	125	10.0	175	8.6	.....	.....	.....	.....	19
13	.....	.....	155	10.8	205	9.4	260	7.5	.....	.....	18
14	.....	.....	185	11.8	250	10.2	305	8.4	335	6.3	15
15	.....	.....	225	12.8	295	11.1	360	9.1	395	6.9	21
16	.....	.....	265	13.7	350	11.9	425	9.9	465	7.6	37
17	.....	.....	315	14.8	410	12.8	495	10.6	540	8.3	28
18	.....	.....	365	15.9	475	13.9	570	11.5	625	9.1	34
19	.....	.....	415	16.9	540	14.9	645	12.4	715	9.9	22
20	.....	.....	470	17.9	610	15.9	730	13.3	820	10.7	20
21	.....	.....	525	18.9	690	16.9	825	14.2	935	11.5	21
22	.....	.....	580	19.8	775	17.8	935	15.2	1,065	12.4	30
23	.....	.....	640	20.8	865	18.8	1,050	16.2	1,205	13.2	20
24	.....	.....	700	21.8	955	19.7	1,165	17.1	1,350	14.1	23
25	.....	.....	760	22.8	1,045	20.8	1,285	18.1	1,500	14.9	16
26	.....	.....	825	23.7	1,145	21.8	1,415	19.0	1,650	15.8	19
27	.....	.....	.....	.....	1,250	22.6	1,545	19.9	1,810	16.6	12
28	.....	.....	.....	.....	.....	.....	1,675	20.9	1,970	17.5	5
29	.....	.....	.....	.....	.....	.....	1,815	21.7	2,130	18.5	8
30	.....	.....	.....	.....	.....	.....	1,955	22.6	2,290	19.3	5
											441

[1] Measured outside bark.

TABLE 20.—*Volume in board feet of cypress based upon breast-high diameters, by Doyle and the two-thirds log rule (South Carolina).*

Diameter breast high.	Doyle rule.	"Two-thirds" rule.	Total height.	Used length.	Length of log.[1]	Stump height.	Diameter (inside bark) of top.	Basis.
Inches.	*Bd. ft.*	*Bd. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Inches.*	*Trees.*
10	20	64	65	40	.....	2.7	5.6	.....
11	37	84	69	41	.....	2.7	6.2	.....
12	54	105	73	42	20	2.8	6.8	3
13	72	127	76	44	19	2.8	7.4	4
14	92	150	79	45	19	2.9	8.0	2
15	115	174	81	46	18	2.9	8.5	6
16	141	200	83	47	19	3.0	9.1	9
17	169	228	85	48	19	3.0	9.7	2
18	200	258	86	49	19	3.1	10.3	5
19	234	289	87	49	19	3.2	10.8	10
20	271	322	88	50	19	3.2	11.4	11
21	312	361	89	51	18	3.3	12.0	9
22	359	403	90	52	18	3.3	12.6	7
23	413	450	91	53	18	3.3	13.2	7
24	473	500	92	54	18	3.4	13.7	14
25	541	555	93	54	17	3.4	14.3	13
26	613	610	94	55	19	3.5	14.9	13
27	686	667	95	55	18	3.5	15.5	9
28	760	720	95	56	18	3.6	16.1	10
29	832	775	96	56	19	3.6	16.7	14
30	916	830	97	57	18	3.6	17.2	15
31	979	881	98	57	18	3.7	17.8	12
32	1,050	935	98	58	18	3.7	18.3	4
33	1,121	990	99	58	18	3.8	18.8	6
34	1,193	1,040	100	59	19	3.8	19.2	14
35	1,262	1,094	101	59	18	3.8	19.6	10
36	1,333	1,150	101	60	19	3.8	20.0	9
37	1,405	1,203	102	60	18	3.9	20.4	12
38	1,476	1,259	103	60	18	3.9	20.8	7
39	1,546	1,312	104	61	19	3.9	21.1	3
40	1,615	1,369	104	61	18	3.9	21.4	9

[1] Uncurved.

TABLE 20.—*Volume in board feet of cypress based upon breast-high diameters, by Doyle and the two-thirds log rule (South Carolina)*—Continued.

Diameter breast high.	Doyle rule.	"Two-thirds" rule.	Total height.	Used length.	Length of log.	Stump height.	Diameter (inside bark) of top.	Basis
Inches.	*Bd. ft.*	*Bd. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Inches.*	*Trees.*
41	1,683	1,424	105	61	19	4.0	21.7	2
42	1,752	1,480	106	62	18	4.0	22.0	2
43	1,821	1,538	107	62	.....	4.0	22.3	.....
44	1,890	1,591	108	62	19	4.0	22.6	5
45	1,959	1,649	108	63	18	4.1	22.9	2
46	2,025	1,701	109	63	16	4.1	23.1	1
47	2,092	1,759	110	63	18	4.1	23.4	1
48	2,160	1,815	111	63	18	4.1	23.6	3
49	2,230	1,872	111	64	.....	4.1	23.9	.....
50	2,300	1,930	112	64	.....	4.1	24.1	.....
								265

TABLE 21.—*Volume of merchantable cypress in board feet by the Scribner and Doyle rules for cypress in Louisiana.*[1]

Diameter outside bark at 20 feet.	Diameter breast-high.	Volume.		Total height.	Merchantable length.	Length of log.[2]	Stump height.[2]	Diameter inside bark of top.	Basis trees.
		Scribner.	Doyle.						
Inches.	*Inches.*	*Board feet.*	*Board feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Inches.*	
8	12.8	.....	20	65	33	.....	.....	5.5	.....
9	14.2	50	40	70	36	33	3.8	6.2	2
10	15.6	95	60	75	40	.....	.....	6.9	.....
11	17.0	140	80	79	43	56	3.7	7.6	1
12	18.4	190	110	84	47	28	3.9	8.3	6
13	19.8	240	140	88	50	24	3.5	9.1	4
14	21.1	290	180	91	54	31	3.7	9.8	5
15	22.4	350	230	95	57	22	3.6	10.5	7
16	23.8	410	280	98	59	23	3.7	11.2	8
17	25.1	490	340	101	62	24	3.7	11.9	5
18	26.3	560	400	103	64	14	3.5	12.6	2
19	27.6	650	480	105	66	33	3.9	13.3	4
20	28.8	740	560	107	67	33	3.2	14.0	1
21	30.0	840	660	109	69	34	3.2	14.6	1
22	31.2	950	770	111	70	20	4.2	15.3	2
23	32.4	1,080	890	113	71	25	3.0	15.9	1
24	33.6	1,210	1,020	114	72	39	3.5	16.6	1
25	34.7	1,350	1,170	116	73	.....	.....	17.3	.....
26	35.9	1,510	1,330	117	73	.....	.....	17.9	.....
27	37.1	1,670	1,500	118	74	36	3.5	18.6	1
28	38.2	1,850	1,680	119	75	30	5.0	19.3	2
29	39.4	2,020	1,870	120	75	28	4.0	19.9	1
30	40.5	2,200	2,060	121	76	34	3.5	20.6	1
									55

[1] Based upon measurement of 55 trees and must be considered rather as tentative than final. Tables for South Carolina are generally applicable.
[2] Uncurved.

Referring to Table 18, for example, one learns that a 3-log tree, with a butt log 18 inches in diameter at the upper end contains 400 board feet of merchantable lumber; also that such trees are cut on an average to a top diameter of 12 inches measured inside the bark. The tables are based upon full scale of sound timber. Another form of measurements (Table 20) gives the volume of trees of a specified breasthigh diameter by the Doyle and two-thirds log rules in South Carolina; also the average total height and length, average length of log, stump height, and diameter to which the trunk is utilized.[1]

Although based upon insufficient measurements, Table 21 is included here for reference and comparison. It will be found useful for rough approximation for which

[1] Since these measurements were taken, utilization in logging has advanced considerably, so the figures are likely to be too low in total volume and used length and too high in top diameter and stump height.

it should be considered as sufficiently accurate, but for all practical purposes Tables 20 and 21 are to be preferred since they show the number of logs under each diameter class.

TAPER.

Table 22 shows the form or taper of the base for trees of various diameters measured at 7 feet above the ground in Maryland. The relation of height to diameters measured at breastheight for trees in Maryland and Louisiana is given in Tables 23 and 24. Table 23 is based on too few trees to be reliable, but serves as an indication of the relative form.

TABLE 22.—*Basal taper of cypress in Maryland for trees of various diameters.*[1]

Diameter at 7 feet (outside bark).	Diameter inside bark.				Basis.	Diameter at 7 feet (outside bark).	Diameter inside bark.				Basis.
	1 foot above ground.	3 feet above ground.	4.5 feet above ground.	5 feet above ground.			1 foot above ground.	3 feet above ground.	4.5 feet above ground.	5 feet above ground.	
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Trees.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Trees.*
1	2.8	2.0	1.8	1.2	.....	19	38.0	26.1	.....	20.7	9
2	4.4	3.1	2.9	2.2	.....	20	40.1	27.6	.....	21.8	14
3	5.9	4.2	3.9	3.3	.....	21	42.2	29.1	.....	22.9	6
4	7.6	5.3	5.0	4.3	.....	22	44.1	30.5	.....	24.1	6
5	9.4	6.5	6.1	5.3	4	23	46.1	32.0	.....	25.2	3
6	11.4	7.7	7.2	6.4	2	24	48.0	33.5	.....	26.4	4
7	13.5	8.9	8.4	7.5	5	25	49.8	34.9	.....	27.6	4
8	15.5	10.1	9.5	8.5	10	26	51.6	36.4	.....	28.8	2
9	17.6	11.4	10.6	9.6	5	27	53.3	37.8	.....	30.1	1
10	19.6	12.7	11.8	10.7	5	28	55.0	39.3	.....	31.2	2
11	21.6	14.1	13.0	11.8	8	29	56.7	40.7	.....	32.5	2
12	23.6	15.5	14.2	12.9	7	30	58.3	42.1	.....	33.7	.....
13	25.7	17.1	15.5	14.0	7	31	60.0	43.6	.....	34.8	2
14	27.8	18.7	16.7	15.1	8	32	61.6	45.1	.....	36.0	1
15	29.8	20.3	17.9	16.2	6	33	63.3	46.5	.....	.....	.....
16	31.9	21.8	19.1	17.3	8	34	64.9	48.0	.....	.....	1
17	33.9	23.3	.....	18.4	3	35	.....	49.4	.....	.....	.....
18	36.0	24.7	.....	19.5	7	36	.....	50.9	.....	.....	.....
											142

[1] Diameters measured at 7 feet above the ground instead of breasthigh.

For trees of known diameter at breastheight up to 20 inches, the taper at 1, 3, 5, and 7 feet above the ground is shown in Table 23.

TABLE 23.—*Height and clear length of virgin cypress in Louisiana based upon diameter.*

Diameter outside bark at 20 feet.	Diameter breast-high.	Height.			Clear length.	Basis.
		Maximum.	Average.	Minimum.		
Inches.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Trees.*
8	12.6	79	65	51	39	.....
9	14.2	85	70	55	43	2
10	15.6	91	75	58	47	.....
11	17.0	96	79	62	50	1
12	18.4	100	84	65	53	6
13	19.8	105	88	68	56	4
14	21.1	108	91	70	59	4
15	22.4	112	95	73	61	7
16	23.8	115	98	76	63	8
17	25.1	117	101	78	65	5
18	26.3	120	103	81	66	2
19	27.6	122	105	83	68	3
20	28.8	124	107	85	69	.....
21	30.0	125	109	87	71	1
22	31.2	127	111	89	72	2
23	32.4	128	113	90	73	1
24	33.6	129	114	92	75	1
25	34.7	130	116	93	76	.....
26	35.9	131	117	95	77	.....
27	37.1	132	118	96	78	1
28	38.2	133	119	97	80	2
29	39.4	134	120	98	81	1
30	40.5	135	121	100	82	1
						52

TABLE 24.—*Height of virgin cypress in Maryland on basis of diameter.*

Diameter breast-high.	Height.			Basis.	Diameter breast-high.	Height.			Basis.
	Maximum.	Average.	Minimum.			Maximum.	Average.	Minimum.	
Inches.	*Feet.*	*Feet.*	*Feet.*	*Trees.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Trees.*
1	16	12	9	19	18	112	89	74	13
2	27	19	13	53	19	115	92	76	16
3	37	26	18	17	20	116	94	79	10
4	45	32	22	14	21	118	96	81	15
5	53	38	29	12	22	120	98	82	9
6	61	44	31	12	23	121	100	84	9
7	67	49	35	1	24	123	101	86	15
8	73	54	40	5	25	124	102	87	7
9	79	59	44	2	26	125	103	88	5
10	84	63	48	5	27	126	104	90	7
11	89	67	52	9	28	127	105	91	12
12	93	71	55	13	29	127	105	91	3
13	97	74	59	11	30	128	106	92	
14	101	78	62	16	31	129	106	93	4
15	104	81	66	13	32	129	106	94	2
16	107	84	69	16					
17	110	87	71	10					355

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